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**ASSESSMENT OF HEALTHCARE
WASTE MANAGEMENT IN THE UAE
WITH EMPHASIS ON RADIOACTIVE WASTE**

**A Thesis Submitted in Partial Fulfillment for the Degree of
M. Sc. in Environmental Science**

By

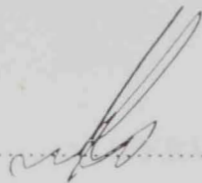
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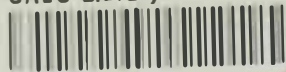
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ABSTRACT

During coastline cleaning campaign carried out in the UAE in 1993, various amounts of waste classified as medical waste were identified. As a result, public concern has been raised concerning the handling and disposal of medical waste in the country. Despite that, little work has been conducted to assess medical waste management in the UAE and no published work has been found that assesses the management of radioactive medical waste. The main objective of this research was to assess the process of implementation of medical waste management applied at major hospitals in the UAE in comparison with the guidelines established by the World Health Organization (WHO). Such assessment included the procedures for handling, collection, transportation, treatment and disposal of generated medical waste.

A questionnaire that accounts for all steps of waste management was distributed to 14 hospitals located in the different emirates within the UAE. Additionally, direct onsite visitation of selected hospitals was performed to collect information that would result in a better assessment of waste management and guideline implementation. On the applied side, ash samples were collected from hospitals with incinerators to measure its radioactive and metal content.

Results of this study revealed that the average rate of medical waste generated at UAE hospitals is 1.95 kg/bed/day, with high variations among the surveyed hospitals (i.e. 0.2 to 4.5 kg/bed/day). While the total quantity of medical waste generated at UAE hospitals is known, most of the hospitals do not estimate the quantity of each type of

medical waste generated. Segregation procedure for generated medical waste at UAE hospitals is applied for pathological, sharps, and infections waste. However, not all the surveyed hospitals are practicing segregation for other types of medical waste including chemical, pharmaceutical, and pressurized containers. Collection of hospital waste is usually conducted using two types of color-coded bags: yellow for medical waste and black for domestic waste. It was found that not all hospitals practice marking on their disposed bags and containers neither are they employing waste tracking system during transportation. Separate on-site storage room for medical waste exists at many hospitals.

Most of the hospitals in the UAE do not have pretreatment capabilities for medical waste possibly due to budget constraints or due to the wide use of disposable items. Some hospitals, however, are using certain types of pretreatment methods including autoclave and chemical disinfection for pathological and infectious waste. Other types of pretreatment methods such as microwave, gas/vapor, and irradiation are not used by any of the surveyed hospitals. Among the treatment methods for medical waste, incineration is used by many hospitals in the UAE. However, most of the incinerators are old and poorly maintained with no proper equipment to control air pollution. Hospitals in the city of Abu Dhabi are using continuous feed technology for destruction of infectious pathogens in generated medical waste while hospitals in the city of Dubai are disposing their medical waste in a sanitary landfill.

Federal regulations that govern management of medical waste are not clearly developed in the country. Guidelines for medical waste management, excluding

radioactive waste, have implemented. Major hospitals have developed some guidelines for management of their own medical waste. While these guidelines are strictly followed at some hospitals, it is left to the hospital administrators to implement their established guidelines and procedures. Greatly lacking are federal or internal guidelines for the management of radioactive medical waste.

All radionuclides used at UAE hospitals have relatively short half-lives. Surveyed hospitals using radionuclides have special storage facilities for their radioactive waste with a decay storage period that varies from two to three weeks and could reach six months in certain cases, depending on the isotope present in the waste. Analysis of ash samples collected from incinerators of hospitals using radionuclides showed that the level of activity is below the limit recommended by the International Atomic Energy Agency. Furthermore, analysis of ash samples showed that toxic metals, with the exception of chromium at certain locations, do not exceed the TCLP regulatory limits.

It is recommended that a competent authority coordinates with other sectors in the country to establish a federal policy for management of medical waste including the radioactive portion. It is further recommended that municipalities provide the necessary infrastructure for collection, transportation, and disposal of medical waste and enforce the provisions of the law for medical waste management.

Better management of medical waste can be achieved if a hospital coordinate activities among its different departments. Hospital managers should train their staff to become aware of the the hazards associated with infectious or toxic waste. Immunization against Hepatitis B should be given to all hospital workers at risk especially nurses, auxiliaries and porters. It is also recommended that hospitals document all cases of infection or poisoning result from exposure to or handling of medical waste.

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CHAPTER I

INTRODUCTION AND OBJECTIVES

1.1 INTRODUCTION

Solid waste is all unwanted products generated from human and animal activities. Modern development of human life styles has led to increasing rates of generated solid wastes and consequently the breeding of rats and fleas associated with disease vectors. The United States Public Health Service has published studies tracing the relationships of twenty-two human diseases that can result due to improper solid waste management (Tchobanoglous et al., 1993). In addition to public health problems, ecological problems such as water and air pollution have also been attributed to improper disposal of solid wastes.

The rate of generation of solid waste increases significantly in more industrialized countries along with the increase in the standard of living. The rate is also affected by the management system in terms of increasing human awareness and recycling efforts the extent of agricultural activities in the country. Therefore, several sectors contribute to the amount of solid waste generated including industrial, municipal, and agricultural sectors. The focus of this study is on the portion of waste that is generated by the medical sector.

In the past two decades, public concern over the improper handling and disposal of medical waste has markedly increased. This concern was stimulated by the various reports of such wastes being washed up on beaches of the east and west coasts of the United States, as well as on beaches of Europe, Asia and South America (Debra, 1989). This resulted in a number of beach closings and loss in revenues to the tourist industries in these areas. Public fear steamed from the risk of contamination and transmission of human immunodeficiency virus (HIV), hepatitis B virus (HBV) and other agents associated with blood borne diseases. While there also have been rare and isolated instances of public exposure, such as the report in 1987 of children in Indianapolis, Indiana, who were found playing with needles and vials discarded by a doctor's office, the literature shows no instances of public illness caused by such exposures.

Burke (1994) conducted a survey of recent literature on medical waste and concluded that "the consensus in the recent articles on medical waste is that medical waste is no more dangerous than non-medical waste". Also as reported by Burke (1994) and the references therein, the US Environmental Protection Agency (EPA), the National Institute of Health (NIH) and the Centers for Disease Control (CDC) argued that medical waste constituted no more of a health hazard than any other form of municipally generated solid waste. Although the predominant body of scientific literature supports the assertion that the real risk of acquiring an infectious disease through contact with biomedical waste is extremely low, the general population perceives the risk of contracting a disease or illness from these materials to be extremely high (Lichveld et al., 1992).

The major portion of hospital waste consists of general domestic waste, usually originating from offices and kitchen activities within the hospital. Public concern is related, however, to the other portion of this waste, which includes chemical, pharmaceutical, infectious, and pathological wastes that are considered hazardous to human health. These types of waste require special guidelines for handling and disposal. Radioactive excreta from nuclear medicine patients and medical biohazards waste can also enter solid waste as common trash in some countries. Landfill administrators and transfer stations are surveying these waste streams with scintillation detectors, which may result in rejection of a particular hospital's waste in some countries.

-Since the inception of the United Arab Emirates in 1971, the government has spared no effort in building up a modern state with a view of providing a safe environment for the welfare of its people in order to realize their promising aspiration in the march of progress and development. During the past three decades, the UAE has witnessed an unprecedented progress in many fields (Annual Book, 1999). Development indicators are reflected in various forms including population growth, educational development, individual's average age, standard of living, and the keenness of the country on protecting and preserving the wildlife and the environment.

In 1980 the population of the UAE was 1.42 million. The population then increased to 2.94 million by 1999 according to a report by the Ministry of Planning (Annual Book, 1999). Tremendous progress and development in the health sector have been achieved in the UAE. In the early seventies, for example, there were few

facilities available to the general population in terms of organized medical treatment. At that time, there were only 7 hospitals and 12 health centers with a total of 70 beds. In 1999, the number of hospitals has risen to 30 with 4681 beds excluding those hospitals and health centers affiliated with the Department of Health and Medical Services in Dubaï, Ministry of Defense, Ministry of Interior, and Oil Companies.

Primary health care services have been developed in such a manner as to secure the provision of such services throughout the country. These centers provide curative and preventive services as well as dental services and health awareness. Basic diagnostic services including laboratory testing and X-ray have also been. The number of patients attending these centers has reached 4.8 million attendants. Today there is one doctor for every three families and one nurse for every family in the country, totaling 1535 doctors and 4664 nurses. School health services have expanded over the last three decades. In the early seventies, for example, there were only four doctors, two dentists, and thirty nurses who provided school health service to 129 schools with about 40,000 students. In 1998, the number of doctors, dentists, and nurses had increased to 82, 22, and 373, respectively who provided services for 615 schools with 295,000 students (Annual Book, 1999).

In spite of the development of the health sector in the country, federal regulations that govern management of medical waste are not clearly developed. Guidelines for medical waste management have been developed in some emirates, like Abu Dhabi and Dubai, but they are not strictly implemented. All major hospitals in the country have developed some guidelines for management of their own hospital waste. These guidelines include procedures for collecting, handling, transporting and

disposal of hospital generated waste. While these guidelines are strictly followed at some hospitals, it is left to the hospital administrators to implement their established guidelines and procedures.

Lack of regulations concerning medical waste management and weak enforcement of these regulations once they have been established may cause some environmental problems. During a coastline cleaning campaign carried out in the UAE in 1993, various amounts of waste that can be classified as medical waste were identified. As a result, public concern has been raised concerning the handling and disposal of medical waste in the country. Despite that, little work has been conducted to assess hospital waste management in the UAE (Al-Numairy, 1994; Shuwaiter, 1995). Although good results have been accomplished in these previous studies concerning waste quantification, none of the reports considered radioactive waste produced at health care centers. Also, these reports did not focus on the implementation aspect of the guidelines concerning management of medical waste. According to the UN Development Program in UAE, a study by the Infection Control Committee at Aljazeera hospital showed that every patient cost about Dhs 9,500 as a result of being sick due to disease spread by infection inside the hospital (UN Development Program, 1998).

Of relevance to this work is a study that was conducted by Tom Hall Consultants (1998) concerning management of health care waste in Abu Dhabi. The study is entitled "Waste Management in Abu-Dhabi", and consists of several reports, including: (1) Disposal of health care waste, code of practice; (2) Radioactive waste management for hospitals; (3) The management of health care waste, outline action

plan, policy and strategy; and (4) The management of health care waste, waste management audits. These reports were submitted to the Center for Food and Environment Control, however access to view these reports was not possible.

Waste generated at hospitals may undergo several processes before being ultimately disposed of into the environment (Fig.1) Waste handling will be employed from the point of generation until the waste is treated and disposed of. The waste could be stored before being treated on site or transported off-site for treatment. Management of medical waste requires that health and safety issues associated with the above-mentioned aspects be properly addressed.

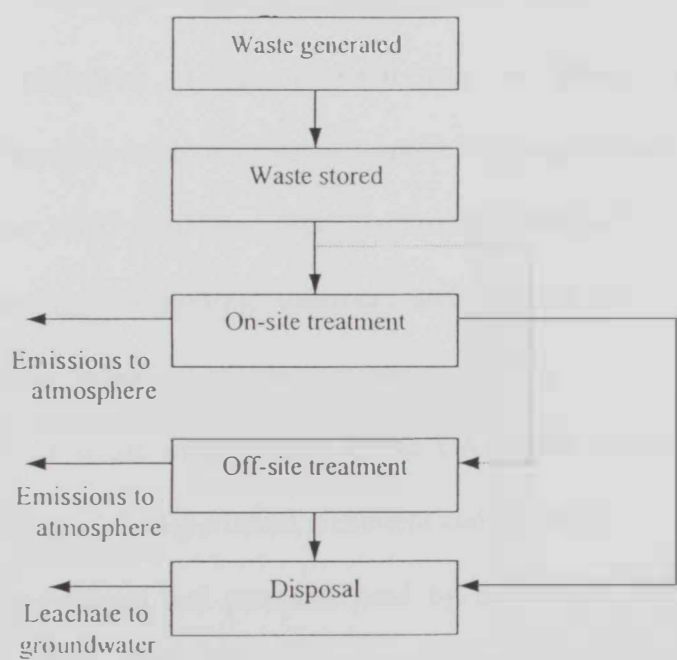


Fig. 1.1 Medical waste management and potential environmental pollution.

1.2 OBJECTIVES AND APPROACHES

Medical waste is a growing, pressing problem with the expectation that it will become more complex in the future. The importance of properly managing medical waste has lead the World Health Organization (WHO) to launch an informative site (www.healthcarewaste.org) that aims to provide practical information on health-care waste management options which may be suitable for developing countries. With more stringent environmental regulations, the expense of proper disposal of this medical waste will probably be escalated in a manner that would increase the cost of health provision. These costs, in turn, will possibly be passed onto the patient.

The main objective of this research was to assess the process of implementation of medical waste management applied at major hospitals in the UAE in comparison to the WHO guidelines. Such assessment will include the procedures for handling, collecting, transporting, treatment and disposal of generated medical waste. Specifically, the objectives of this study were:

1. To assess medical waste management in the UAE with regards to labeling, segregation, collection, transportation, treatment and disposal.
2. To assess the guidelines and practices used by the various hospitals in the country dealing with the various types of generated medical waste.
3. To assess the practice used for disposal of radioactive waste generated at the hospitals and to analyze the incinerator ash for its radioactive and metal content.

To achieve the above objectives a questionnaire was formulated and prepared in manner that would address the points critical to the assessment of medical waste management in the country. The questionnaire was distributed to all major public and some private hospitals in the country. Additionally, the assessment included direct onsite visitation of selected hospitals to collect information that would result in a better assessment of waste management and guideline implementation. On the applied side, ash samples were collected from hospitals with incinerators to measure its radioactive and metal content.

1.3 THESIS STRUCTURE

This thesis consists of six chapters. Chapter 2 presents a review of the literature pertaining to the components of medical waste management including segregation, handling, transportation, treatment and disposal as well as established legislation and regulations. The chapter also presents previous work related to medical waste in the UAE. The last section of Chapter 2 is devoted to review the types of radionuclides at hospitals and the management aspect of radioactive medical waste. Chapter 3 describes the process of distribution of the questionnaire and the experimental procedure used to analyze ash samples from incinerators for activity and metal content. Assessment of medical waste management in the UAE is presented and discussed in Chapter 4. The assessment is solely based on responses received for the distributed questionnaire as well as on-site visitation to the selected hospitals. In Chapter 5, results obtained from analysis of ash sample for activity level and metal content are presented and discussed. Finally, Chapter 6 concludes this study and draws recommendations related to management of medical waste in UAE.

CHAPTER 2

REVIEW OF MEDICAL WASTE MANAGEMENT

Proper management of medical waste requires characterization and quantification of generated waste and methods of handling, treatment and disposal of the waste to meet established standards and regulations. Additionally, a necessary component of any management strategy should consist of possible means to reduce or eliminate the generated waste. This chapter presents an overview of medical waste management. Definitions of the different types of waste generated at hospitals or health care facilities are first presented.

2.1 DEFINITIONS

Development of a useful waste management framework should distinguish between the meanings of the different terms pertinent to the subject. Therefore, the following are definitions of the different types of waste encountered at hospitals or medical centers.

Waste: The word “waste” refers to useless, unused, unwanted, or discarded materials.

Waste includes solids, liquids, and gases. The gases are principally industrial fumes and smoke; the liquids consist mainly of sewage and the fluid part of industrial wastes; the solids are classified as refuse.

Solid Waste: The term “solid waste” refers to “refuse” and the two are used more or less synonymously. Because “solid waste” is somewhat more descriptive and therefore less subject to misinterpretation it is being used more and is supplanting

the term refuse. Solid wastes can be classified in several different ways. One such classification is related to the waste point of origin. In such a case waste is classified as domestic, institutional, commercial, industrial, street, demolition or construction. Another means of classification is related to the solid waste composition. In this case, the waste is related to the nature of the material and classification may be made on the basis of organic or inorganic characteristics combustibility or noncombustibility, putrescibility or nonputrescibility, toxicity and its hazardous nature. One other classification is based on the type of waste materials. Thus waste is classified as garbage, rubbish, ash, street refuse, dead animals, abandoned automobile, industrial waste, demolition waste, construction waste, sewage solids and hazardous and special wastes (Municipal Refuse Disposal, 1970).

Hospital Waste: All solid waste, both biological and non biological, that is produced at a hospital and is discarded and not intended for further use. The term “hospital waste” is used interchangeably with the term “health care waste”. The WHO (1985) classified hospital waste into eight main categories:

1. General waste: includes domestic-type waste, packing materials, non-infectious, animal carcasses, bedding, wastewater from laundries and other substances that do not pose a special handling problem or a hazard to human health or the environment.
2. Pathological waste: includes tissues, organ, body parts, human fetuses, animal carcasses, and most blood and body fluids.
3. Radioactive waste: includes solid, liquid, and gaseous waste contaminated with radionuclides generated from in vitro analysis of body tissues and fluid, in vivo body organ imaging, tumor localization and therapeutic procedures.

4. Chemical waste: includes discarded solids, liquid, and gaseous chemicals originating from diagnostic and experimental work, housekeeping, cleaning, and disinfecting procedures.
5. Infectious waste: includes waste that contains pathogens in sufficient concentration so that exposure could result in disease. This includes blood, sharps, wastes from the hospital centers of microbiology, communicable disease, pathology, and autopsy, and contaminated animal carcass waste as well as waste generated from surgical dialysis and laboratories.
6. Sharps: includes needles, syringes, scalpels, saws, blades, broken glass, nails, and any other item that could cause a cut or puncture.
7. Pharmaceutical waste: includes pharmaceutical products, drugs and chemicals that have been returned from the ward, have been spilled, outdated, contaminated, or are to be discarded because they are no longer required.
8. Pressurized containers: includes those used for demonstration or instructional purposes, containing innocuous or inert gas, and aerosol cans that may explode if incinerated or accidentally punctured.
9. Genotoxic waste: Waste containing substances with genotoxic properties e.g. waste containing cytotoxic drugs (often used in cancer therapy), genotoxic chemicals. (www.who.int)
10. Wastes with high content of heavy metals: e.g. batteries, broken thermometers, blood pressure gauges. . (www.who.int)

Medical waste: A subset of hospital waste that is defined by the US Environmental Protection Agency (EPA) as: “Any solid waste which is generated in the diagnosis, treatment, or immunization of human beings or animals, in research pertaining to, or in the production or testing of biological samples” (Code, 1994). This definition

covers the seven categories (category 2 through 8) of the WHO hospital waste definition listed above.

Hazardous waste: There is no specific or universal definition for hazardous waste. Some countries consider waste to be hazardous only when it poses a danger to human health. Other countries go further, to include all industrial wastes in this category. According to United Nation Environment Program (UNEP), hazardous waste is defined as: “waste other than radioactive waste, which because of its chemical reactivity or toxic, explosive, corrosive or other characteristic causes danger, or likely to cause danger, to health or the environment, whether alone or when comes into contact with other waste...”. Hazardous wastes covered by the Basal Convention were further specified in Article 1 of the convention. Wastes were categorized and listed in annexes to the Convention (Kanbour, 1994). The American Resource Conservation and Recovery Act (RCRA) defines hazardous waste as any waste that possesses a characteristic of ignitability, reactivity, corrosivity or toxicity (Wentz, 1989). As with the UNEP definition, radioactive waste is not included in RECR’s definition of hazardous waste. In the UAE, there is no unified definition of hazardous waste. For example, Abu Dhabi National Oil Company (ADNOC) adopted the RCRA’s definition while Dubai Municipality (1998) accounts for these types of hazardous waste but also includes clinical and biological wastes that can cause infectious diseases.

Radioactive waste: Any material that contains or is contaminated with radionuclides at concentrations or activities greater than clearance levels as established by the regulatory body, and for which no use is foreseen. This definition is purely for regulatory purposes, and that material with activity concentrations equal to or less

than clearance levels is radioactive from a physical viewpoint although the associated radiological hazards are considered negligible (Efremenkov, 1997).

Although beyond the scope of this study, health-care establishments generate wastewater of a similar quality to domestic wastewater, but may contain high content of enteric pathogens. Wastewater from health-care establishments may also contain small amounts of hazardous chemicals, pharmaceuticals, and radioactive isotopes. Detailed discussion of appropriate means for collection and disposal of wastewater from health-care establishments is presented by WHO (1999).

2.2 WASTE CHARACTERIZATION AND QUANTIFICATION

2.2.1 Characterization

The overriding characteristic of hospital waste is its heterogeneity. A sample of hospital waste may contain paper, plastics, food wastes, animal carcasses, pathological wastes, intravenous bags, blood-soaked bandages and many other types of materials (Lee et al., 1996). While the composition of a hospital waste is similar in many of its components to municipal wastes, it is unique in that it contains potentially infectious and hazardous elements.

Hospital waste varies in the percentage of its components relative to that of municipal waste. For example, the amount of plastics in hospital waste ranges between 20% (Doyle et al., 1985) to 28% (Peters, 1991), while that commonly reported in municipal waste is about 3.7% (Doyle et al., 1985). The results of medical

waste characterization at two large hospitals in the state of Florida show that more than 80% of the waste stream consists of plastic, paper, and cotton, with the plastic percentage (32%) being the highest in the waste stream (Wong and Narasimhan, 1994). Within the plastics, polyvinyl chloride, the main source of hydrochloric acid gas upon incineration, was present in an appreciable amount. An extensive survey conducted at a Saudi hospital (Hagen et al., 2001) showed a continuing trend in a higher percentage of plastics and a decrease in paper due to increased use of disposable materials. Hagen et al. (2001) claimed that after implementation of a waste segregation program at this hospital, a waste reduction of 65% was achieved.

WHO (1985) summarized the different categories included in the definition of hospital waste by-source of health care service as presented in Table 2.1. The UK Health and Safety Commission (1992) categorized the fraction of hospital waste that is considered hazardous into five groups:

Group A: includes pathological waste.

Group B: includes discarded syringe needles and contaminated sharps.

Group C: includes infectious waste.

Group D: includes certain pharmaceutical products and chemical waste.

Group E: includes disposable bed-pan liners, urine containers, incontinence pads and stoma bags.

As quoted by Birchard (2002), WHO believes that 20% of the waste generated by medical facilities and practices can be classified as hazardous materials that may be infectious, toxic or radioactive.

Table 2.1 Categories of waste produced by different types of health-care services (WHO, 1985).

Source	Category*							
	1	2	3	4	5	6	7	8
Patient Service								
Medical	•	•		•	•	•	•	•
Surgical	•	•		•	•	•	•	•
Operating theater	•	•		•	•	•	•	•
Recovery and intensive care	•	•		•	•	•	•	•
Isolation ward	•	•		•	•	•	•	
Dialysis unit	•	•		•	•	•	•	
Oncology unit	•	•		•	•	•	•	
Emergency	•	•		•	•	•	•	
Outpatient clinic	•	•		•	•	•	•	
Autopsy room	•	•		•	•	•		
Radiology	•	•		•	•	•		
Laboratories								
Biochemistry	•	•	•	•	•	•		
Microbiology	•	•	•	•	•	•		
Hematology	•	•	•	•	•	•		
Research	•	•	•	•	•	•		•
Pathology	•	•	•	•	•	•		
Nuclear medicine	•	•	•	•	•	•		
Support Service								
Blood bank	•	•		•	•	•		
Pharmacy	•			•				
Central sterile supply	•			•			•	•
Laundry	•			•		•		
Kitchen	•			•				
Engineering	•			•		•		•
Administration	•							
Public areas	•							
Long Term Health Care Establishments	•			•	•	•	•	•

* Numbers correspond to: 1. General waste. 2. Pathological waste. 3. Radioactive waste. 4. Chemical waste. 5. Infectious waste. 6. Sharps. 7. Pharmaceutical waste. 8. Pressurized containers.

2.2.2 Quantification

An effective medical waste management program should consider the rate of waste produced as well as the total quantity. Nowadays, most hospitals are using disposable items, which increase the generated quantity of medical waste. It is

estimated that some 6700 tons of waste are generated by US hospitals daily (Rutala and Weber, 1991), constituting about 1.5% of the 158 million tons of municipal solid waste produced annually in the US. However, a report released by the US Congress (1988), as quoted by Uzych (1990), estimated that about 3.2 million tons of hospital waste are generated yearly, representing about 2% of the total municipal solid waste streams in the US.

Approximately, 15% of hospital waste produced is classified as medical waste. The US EPA (1990), as quoted by Coad (1994), classified and quantified the various medical waste produced by healthcare facilities in the US during the year 1990 (Table 2.2). A total amount of 465,600 tons of medical waste was produced in the US during that year with the majority of the waste being produced by hospitals. This figure is consistent with the 1000 tons of infectious waste produced daily by the US hospitals as reported by Rutala and Weber (1991).

In 1990, the US EPA submitted a report "Medical Waste Management in the United States" to Congress through which it was indicated that each year approximately 456,000 tons of regulated medical waste (RMW) are produced in the US by about 374,000 generators. The report indicated that the vast majority (about 77%) of the RMW is generated by hospitals, which comprises less than 2% of the total number of generators. The remainder is produced by a large, diverse group of generators including laboratories, physicians offices, veterinarians, etc. The majority of these generators produce relatively small quantities (less than 50 pounds per month) of RMW.

Table 2.2 Medical waste produced in the US in 1990 as reported by the US EPA (partially adopted from Coad, 1994)

Source	Quantity (tons)	Percentage
Hospitals	359,000	77.1
Nursing homes	29,600	6.4
Physician offices	26,400	5.7
Clinics	16,700	3.6
Laboratories	15,400	3.3
Dentist offices	7,600	1.6
Veterinarians	4,600	1.0
Funeral homes	3,900	0.8
Blood banks	2,400	0.5
Total	465,600	

Several investigators have reported the daily rate of hospital waste produced per bed in the US. Rutala (1988), as quoted by Hall (1989), indicated that the generation rate of hospital waste in the US is in the range of 16 to 23 lb/bed/day (7.2 to 10.4 kg/bed/day). Quoted by Hall (1989), the US EPA (1989) has estimated the generation rate to be about 13 lb/bed/day (5.9 kg/bed/day). Rutala and Weber (1991) stated that “each hospitalized patient generates about 15 lb (6.8 kg) of hospital waste per day”.

The daily rate of medical waste generated per bed in different countries is listed in Table 2.3. The rate and quantity of medical waste produced as indicated in Table 2.3 are estimated based on information reported by the hospitals. The actual quantity of medical waste in the US produced could be larger due to the existence of other sources that are not accounted for. For example, the U.S Agency of Toxic Substances and Disease Registry (1990), as quoted by Rutala and Weber (1991), reported that there are 2 million diabetics and 1.2 million intravenous drug abusers nation wide who use more than 1 billion insulin-type syringes annually, which are not regulated.

Table 2.3. Rate of medical waste generated in different countries.

Country	Rate of generation (kg/bed/day)	Year of study	Reference
Bahrain	1.8	1997	UNEP/WHO, 1997
Brazil	2.6	1978	Coad, 1994
France	2.9	1991	L.Liberti et al, 1996
Iran	2.7	1997	UNEP/WHO, 1997
Jordan	3.5	1988	Qusus, 1988
Saudi Arabia	1.0	1994	UNEP/WHO, 1994
Morocco	3.2	1997	UNEP/WHO, 1997
Netherlands	2.7	1982	Coad, 1994
Norway	3.9	1983	WHO, 1985
Paraguay	3.8	1989	Coad, 1994
Peru	2.9	1987	Coad, 1994
Spain	2.8	1983	WHO, 1985
UK	2.5	1983	WHO, 1985
USA	4.5	1983	Coad, 1994
Venezuela	3.1	1976	Coad, 1994
India	0.5-2.0	2001	Patil, 2001
Italy	1.4	1991	Liberti et al., 1996

2.3 MANAGEMENT FRAMEWORK

Meany and Pual (1989) suggested that a management plan for medical waste should incorporate a cradle-to-grave approach. This includes the adoption of standard operating procedure to address issues such as waste generation, waste segregation, handling, storage, transportation, treatment and disposal. All these issues should be regulated to assure no occupational or environmental health impact. Furthermore, medical waste management framework may include components such as offerings of training programs to individuals dealing with the waste in all stages from generation until disposal. A schematic diagram for such a plan is presented in Fig. 2.1

2.4 SEGREGATION

Proper separation and identification of medical waste is the key to minimization and therefore, having an effective waste management. Segregation greatly improves public health protection and reduces costs of handling, treatment and disposal. Ideally, segregation of medical waste is carried out in several different fractions according to the specific treatment or disposal requirements of each. Most of the waste within clinics and patient areas (produced by medical staff) is usually carried out by the producer of each item and as close as possible to its point of production. These places are under the direct responsibility of the medical staff.

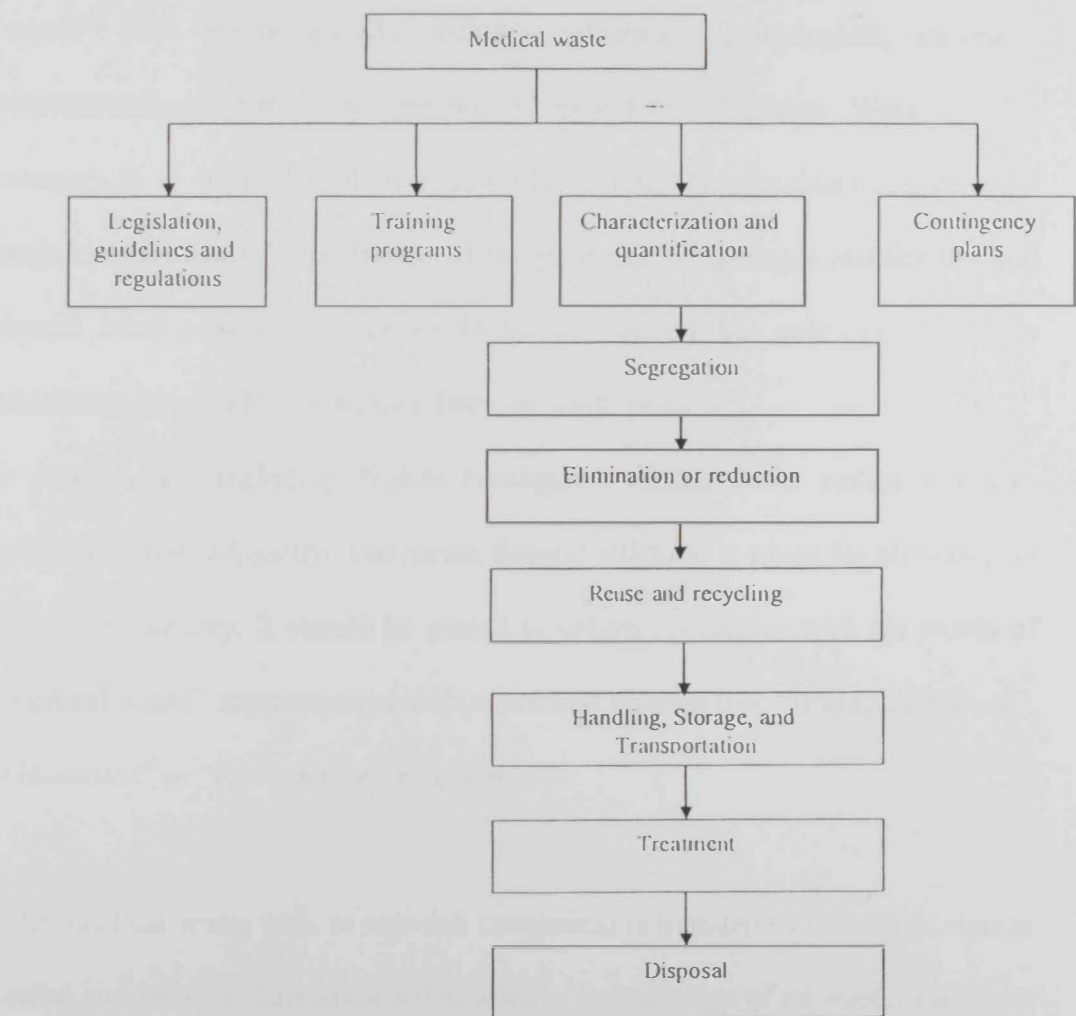


Fig. 2.1 Medical waste management framework.

Medical waste is usually segregated into risk and non-risk categories by the use of color-coded bags, bins, leak-proof boxes or similar containers. Table 2.4 shows guidelines for labeling as recommended by WHO (Basel Convention, 1994). These guidelines are intended for the purpose of segregation. Labels are placed at waste storage areas and waste collection points to remind staff of the correct procedure for segregation (WHO, 1997). A basic system of three segregation categories for medical waste is recommended including:

Non-risk waste: Uncontaminated waste similar to municipal solid waste is normally collected in black plastic bags or containers. Non-risk waste usually represents at least 80% of the total waste production in a medical institution.

Risk waste: This waste usually includes infectious, pathological, chemical, pharmaceutical, sharps and pressurized cylinders categories. Waste in this category is to be collected in yellow plastic bags or containers. Small, rigid containers are used for collection of sharps including syringes and needles and should have a label of "Sharps Only" printed on the side. This category constitutes about 15% of the total hospital waste produced.

Higher risk waste: including highly contagious wastes from isolation wards, genotoxic, and radioactive categories. Special attention is given for all wastes in this third category. It should be placed in yellow containers with the words of "medical waste" supplemented with additional phrases like "Highly Infectious", "Genotoxic" or "Radioactive" as appropriate.

All medical waste (risk or non-risk categories) is transferred from their storage areas sealed and labeled. This assures that sources and contents of all waste containers are known and the quantity of waste produced by each department can be monitored.

This procedure further insures that proper and quick reference could be made back to the originator if there is any waste related problem with the container. WHO guidelines (1997) suggested that general information is to be recorded on a waste container which include: name of institution, name of department or waste generation area, type of waste, name and signature of person sealing container, date sealed and space for other useful information or instructions to support staff or waste workers.

Table 2.4 WHO recommended color coding for biomedical and medical waste (Basel Convention, 1994)

Type of Waste	Color of Container ^a	Type of container
Infectious waste	red ^b	Leak-proof and string plastic bag, or containers supporting autoclaving
Other infectious waste, pathological and anatomic wastes	Yellow	Plastic bag or containers
Sharps	Yellow or red ^c	Puncture-proof containers
Chemical and pharmaceutical waste	brown	Plastic bag or container
Radioactive waste	-	Lead box, labeled with the radioactive symbol
Non-risk medical waste	Black	Plastic bag

^a Proposed color coding system; the use of other color coding in a country is possible.

^b WHO (1997) recommends yellow bags for infectious waste labeled ' highly infectious' .

^c Sharps containers may be yellow if they will be burnt together with other infectious waste, or red if sharps will undergo specific disposal methods such as encapsulation.

2.5 HANDLING, STORAGE AND TRANSPORTATION

The normal procedure for handling medical waste is to segregate the waste according to its type in special containers located in each ward or department. Porters collect these containers regularly and transport them internally to one or more central storage points within the hospital or the institution. At the central storage point, the waste will be segregated before being transported for treatment within the institution or carried away for treatment and disposal outside the institution.

Handling and transporting medical waste within the hospital are designed so as to collect the waste from the temporary storage areas and carry it to one or more secure central storage points away from patients or general public. The management of the hospital usually prepares a waste collection timetable indicating the times during the day waste will be collected from each ward, according to its type as risk and non-risk waste collections. Dedicated trolleys with closed lids are used to transport waste that has already been properly packaged and labeled.

This integrated procedure of collecting and segregating waste at each point of waste generation and transferring such waste to the central storage facility within each institution will enable the maintenance of a good standard of record-keeping. Information can be recorded from each waste being produced by each ward, such as quantity and type. Essential quantity data can be passed on to waste treatment operators, and off-site waste transport documents can be prepared. Transport trolleys are specially designed so as to meet the requirement specified for transporting such waste. They are designed in such away that they do not leak, are easy to clean, and do not trap items of waste or insects or vermin.

Support staff involved in handling medical risk wastes are typically vaccinated for Hepatitis B and Tetanus. In case of accident or other type of emergencies involving contamination of staff members or porters, immediate medical care is provided. Special rules and guidelines are practiced by porters and housekeeping staff including regular checking of waste collection bags or rigid containers to insure that they have been tightly and properly sealed. Bags are also checked for proper labeling and are not supposed to be compressed when placed into the trolley. Other rules

include the wearing of gloves when handling and collecting waste bags. Spillage of waste is regarded as potentially hazardous and picked up as quickly as possible by staff using gloves and protective aprons and placed into another coded bag or bin. This container is labeled and the area is disinfected.

A central area for storage of medical waste is usually allocated within the institution. The area should be locked, with access restricted to authorized personal. It should also be ventilated and large enough to hold the usual generated waste. Also, the waste storage area should be located away from fresh food storage or food preparation areas. It is recommended that medical wastes storage period not to exceed 72 hrs in the winter and 48 hrs in the summer for storage at room temperature, unless a refrigerated storage room is available (WHO, 1997).

Hospital or medical institutions rely on the regular transport of their waste for off-site treatment and disposal to fulfill its primary aim of infection control. Vehicles used for such purpose are closed to avoid spillage of waste and the internal surfaces of these vehicles are washed daily. Transfer of medical waste is usually conducted by the quickest possible route in coordination with hospital management. Vehicles are supplied with documents signed by an authorized person at the intended place of delivery of the waste. The driver and waste handlers (loading and unloading the waste) usually take the same precautions when handling the waste and should be told who to contact at the institution in case of a serious problem or injury.

A login data sheet is kept for recording all waste and is kept in the central storage point. Data sheets can be used for identifying the department from which the

waste is produced. They are also used to estimate waste disposal costs using on-site or off-site treatment and disposal facilities. Data sheets are further used to ensure that on-site waste treatment equipment is not overloaded.

2.6 TRETMENT METHODS

The main objective of medical waste treatment is to reduce the number of pathogens to regulatory, non-harmful limits and minimize its amount. Several treatment technologies may be applied for this purpose (Table 2.5). Not all treatment methods are appropriate for the different types of medical waste (Table 2.5). A brief description of the different treatment methods including limitations and advantages is presented below. It should be noted that some of these technologies might be applied as a pretreatment step before the actual treatment process.

Table 2.5. Medical waste types appropriate for treatment by technology (WHO, 1997)

Technology	Class 1 ^a	Class 2 ^a	Class 3 ^a	Class 4 ^a	Class 5 ^a	Class 6 ^a	Class 7 ^a	Radioactive	Hazardous & Cytotoxic
Incineration	•	•	•	•	•	•	•	• ^b	• ^b
Steam autoclave	•	•	• ^c	•	• ^c	•	•		
Chemical treatment	•	•	• ^c	•	• ^c	•	•		
Microwave	•	•	• ^c	•	• ^c	•	•		
Radio frequency	•	•	• ^c	•	• ^c	•	•		
Gamma irradiation	•	•	• ^c	•	• ^c	•	•		

^a Class 1: Cultures and stocks. Class 2: Pathological. Class 3: Human blood and blood products. Class 4: Sharps. Class 5: Animal. Class 6: Isolation. Class 7: Unused sharps.

^b The treatment of radioactive antineoplastic and hazardous waste which are mixed with medical wastes can be treated with incineration, however, special permits are usually required for this type of treatment. Additionally, incineration does not inactivate radioactive waste. Thus, the ash from these processes may be radioactive or contain hazardous constituents.

^c Technology not recommended for treatment of body parts because the density of the waste may prevent adequate treatment. Grinding the waste may increase treatment. However, the grinding process may present aesthetically unacceptable results.

2.6.1 Incineration

Incineration is a process in which medical waste is burned at high temperature, producing combustion gases and noncombustible residue (ash). Incineration can achieve a reduction of more than 90% of the weight and volume of the solid waste, and greatly reduces the number of microorganisms in the waste. Incinerator can handle all types of medical waste such as cultures and stocks, pathological wastes, human blood and blood products, sharps, animal waste, and isolation waste. Several types of incinerators are used to treat medical waste but the most common ones include multiple chamber, controlled air, and rotary kiln incinerators. Detailed description of these incinerators can be found elsewhere (see US EPA 1989a, b).

Parameters that influence the efficiency of incineration include temperature, negative pressure level, oxygen level, waste characteristics, and waste feed rate. Incinerators operate most effectively with an operation temperature around 1100 °C. Appropriate incinerator design and operators training are essential for destruction of both infectious microorganisms and organic waste. To demonstrate acceptable microbial destruction in specific units, effectiveness tests can be conducted. The organisms of choice for this testing are *B. stearothermophilus* spores. Bacterial spores are more heat resistant than most microbial pathogens, providing a significant challenge to the incinerator (US EPA 1989a, b).

Incinerator ash is produced after every incineration cycle. Ash produced is removed regularly after the cool down period, which may be as long as 8 hrs following the previous burn. The noncombusted residue is disposed of in a landfill. Ash quality is measured by analyzing a sample of the incinerator ash by counting the

number of *B. stearothermophilus* spores. If low-level radioactive, hazardous, or cytotoxic wastes are to be incinerated, special permits are required. In case the incinerator receives low-level radioactive waste, ash samples are analyzed for radioactive levels before disposal.

The generated combustion gases from incinerators are vented directly to the air after treatment with an air pollution control device (APCD). Wet scrubbers and fabric filters are the common APCD used with incinerators to control dust and solid particulate. Air pollutants of environmental concern resulting from incineration of medical waste include dioxin (PCDD) and furan (PCDF) which are highly toxic chemicals and are known to be carcinogenic (Lee & Huffman, 1996). Lee and Hoffman measured the emission of these toxic chemicals from various hospital incinerators and showed that their concentrations are significant and should be controlled. Table 2.6 lists some of the results obtained by the two investigators.

The US EPA reported that medical waste incineration is now the third largest source of dioxin in the environment and accounts for 10% of mercury emissions. Environment Canada reported that biomedical waste incinerators are the second largest source of dioxin emissions in Canada and account for about 9% of the country mercury emissions (Sibbald, 2001). For new incinerators, the standard proposed by the Canadian Council of Ministries of the Environment would limit dioxin emissions to 80 picograms/m³ and mercury emissions to 20mg/m³ by 2006 (Sibbald, 2001). If an incinerator operates inefficiently, further problems could be encountered due to the release of viable pathogens in stack emissions and residue ash (Anyinam, 1994).

Table 2.6 Dioxin/Furan emissions from incinerators (Lee and Huffman, 1996)

Source	PCDD (ng/Nm ³)	PCDF (ng/Nm ³)
Hospital waste incinerators		
Cedar Sinai	160-260	386-700
Saint Agnes	290-450	700-785
Royal Jubilee	117-197	52-84
Municipal waste incinerators		
Hampton	243-10700	400-37500
North Andover	225	323
Marion County	1.13	
Prince Edward Island	60-125	100-160
Tulsa	18.9	15.5
Wurzburg	22.1	27.9
Akron	258	679
Tier IV sources		
Black Liquor	2-17	1.5-45
Wood fired boiler	102	154
Carbon red furnace	28.8	
Sewage sludge	114	---
Drum and barrel	687	

Note: ng/Nm³ = nanogram/normal cubic meter

2.6.2 Autoclave Treatment

Steam autoclave treatment combines moisture, heat and pressure to inactivate microorganisms. This process has been used for sterilizing medical instruments in hospital and the treatment of waste in laboratories. The kind of treatment is however, not suitable for body parts, contaminated animal carcasses, radioactive, hazardous, and cytotoxic waste (Table 2.5). Steam autoclave does not normally include a destruction step in the treatment cycle. Solid waste remains recognizable after treatment, although they may be adequately treated to inactivate all types of microorganisms including bacterial spores. Consequently, liquid waste is usually permitted to be discharged directly to the sanitary sewer. Fugitive air emission may escape with steam. This treatment does not reduce the amount of waste generated.

Steam autoclave is affected by many factors such as temperature, pressure, size of waste load, composition of waste, steam penetration, packaging of waste for treatment and orientation of waste within autoclave. Steam autoclaves operate most effectively when the temperature measured at the center of the waste load approaches 121°C and there is adequate steam penetration of the waste load under pressure.

All steam autoclaves are constructed with a metal chamber to withstand the increased pressure/temperature required to ensure inactivation of bacteria, fungi, viruses, bacteria and bacterial spores. Different autoclaves exist varying in size and means of steam supply. Bench-top autoclaves are small steel body electric device with self-generating steam. These are applicable for waste treatment by laboratories or clinics that generate small quantities of potentially infectious waste each day. Large size laboratory autoclaves are similar in operation to the bench-top model except that they are equipped for direct connection to central steam lines (US EPA, 1993).

Prevacuum onsite autoclave systems are larger devices than the first two types of autoclaves. They are free standing devices and fully jacketed and connected direct to steam lines. The chamber of the prevacuum autoclave is evacuated to a negative pressure prior to the addition of steam. Treatment temperatures in prevacuum autoclaves may reach 135 °C and pressures –35 psi. Treatment cycles may vary from 30 to 55 minutes (US EPA, 1993).

Large volume off-site gravity displacement autoclave system is a very large device. It is applicable only for offsite commercial facilities and has an onsite steam-

generating boiler. Temperature in these devices exceeds 160 °C and pressures of ~85 psi with a treatment cycle of about one hour.

A steam sterilize macerator (SSM 150) produced by the Antacus Group Company transforms infectious medical waste into a confetti-like, non hazardous material that can be disposed of as ordinary trash. The Antacus Group (1999) claimed that, in processing medical waste using such technology, the volume is reduced by about 80% and the weight by up to 15%. The Company further claims that disposal costs are reduced by roughly half as compared to the use of incinerators.

2.6.3 Chemical Treatment

In the chemical treatment of medical waste, antimicrobial chemicals may be used alone or in combination with encapsulating agents or mechanical destruction devices such as shredders or hammermills. Classes of common antimicrobial chemicals and the advantages and disadvantages of each are found in Table 2.7. The effectiveness of the treatment depends upon the characteristics of the chemical, the concentration of active ingredient, the contact time, and the characteristics of the waste being treated. All antimicrobials used for medical waste treatment, either alone or in a mechanical/chemical treatment system, must be tested for efficacy.

Chemical or mechanical/chemical treatment of medical waste is suitable for most waste categories with the exception of body parts and contaminated animal carcasses that may be aesthetically unacceptable. Radioactive, hazardous, and cytotoxic wastes are also excluded from treatment by chemical disinfecting. Chemical treatment in general does not include a destruction step in the treatment

cycle thus the solid waste remains recognizable after treatment. On the other hand, solid waste debris from mechanical/ chemical treatment systems is no longer recognizable. The liquid effluent is frequently discharged directly to the sewer.

Several types of chemical treatment systems exist depending on the size of the system used. The most common include a static system, a recirculating system or a flow-through system. The static system often holds less than 1 gallon of waste materials and solution. It is used in small offices and clinics. Solutions should be prepared to maintain the required use-dilution throughout the day. At the conclusion of the day the solution may be decanted directly to the sanitary sewer and the solid waste material discarded with the municipal waste where permitted.

The recirculating system is applicable for all sizes of medical waste generators because they come in a wide variety of sizes. The solution for chemical treatment is prepared according to the manufacture specifications. The solution is circulated through the waste each time new waste is added to the device before it enters the grinding and shredding chamber where the treatment solution circulates through the waste. However, in the flow-through mechanical/chemical treatment system the chemical solution is automatically diluted to the specified concentration, added to the grinding chamber, and circulated through the waste, as it is being ground. At the conclusion of the grinding and treatment cycle, the solid debris are removed from the solution and after the excess solution has drained from the treated waste, the debris are discarded with the municipal waste provided that such permission is obtained.

Table 2.7. Advantages/ disadvantages of antimicrobial agents (US EPA, 1993).

Class	Advantages	Disadvantages
Alcohols	<ul style="list-style-type: none"> •Bactericidal •Tuberculocidal •Virucidal •Fungicidal •Non-staining •Non-irritating •Rapid action 	<ul style="list-style-type: none"> •Non-sporicidal •Organic matter interference •Incompatible with some rubber and plastics •Highly flammable
Quaternary Ammonium Compounds	<ul style="list-style-type: none"> •Bactericidal •Virucidal (lipophilic) •Fungicidal •Pleasant odor 	<ul style="list-style-type: none"> •Non-tuberculocidal •Non-sporicidal •Organic matter interference •Non-virucidal (hydrophilic)
Phenolic Compounds	<ul style="list-style-type: none"> •Bactericidal •Fungicidal •Tuberculocidal •Virucidal (lipophilic) 	<ul style="list-style-type: none"> •Questionable •Virucide (hydrophilic) •Non-sporicidal •Skin irritant •Unpleasant odor •Corrosiveness
Iodophor Compounds	<ul style="list-style-type: none"> •Bactericidal •Virucidal •Fungicidal •Detergent action •Storage stability 	<ul style="list-style-type: none"> •Prolonged exposure for tuberculocidal and sporicidal activity •Corrosiveness •Inactivation by organic matter
Glutaraldehyde	<ul style="list-style-type: none"> •Bactericidal •Virucidal •Fungicidal •Tuberculocidal •Sporicidal •Lack of organic matter interference •Generally non-corrosive 	<ul style="list-style-type: none"> •Irritant •Limited shelf life
Hypochlorite solution (>500ppm FAC)	<ul style="list-style-type: none"> •Bactericidal •Virucidal •Fungicidal •Tuberculocidal 	<ul style="list-style-type: none"> •Prolonged exposure •Sporicidal activity •Corrosive •Bleaching agent
Hydrogen peroxide	<ul style="list-style-type: none"> •Bactericidal •Virucidal •Fungicidal •Tuberculocidal •Sporicidal 	<ul style="list-style-type: none"> •Corrosive

2.6.4 Nonionizing Radiation Treatment

Nonionizing irradiation of medical waste that will thermally inactivate microorganisms is an adaptation of an existing technology for a new function. There are many factors which effect nonionizing irradiation of medical waste. These factors include the frequency and wavelength of the irradiation, the duration of the exposure, composition and moisture content of the waste material, and the process temperature of the waste achieved and maintained during treatment (US EPA, 1993). Nonionizing radiation processes are used for the treatment of solid treated-waste residuals. This waste may be disposed of with municipal wastes where this is permitted or recycling.

Microwave treatment systems are used either to treat medical waste in small clinical or research laboratories or in large hospitals. The waste is first shredded and then irradiated. Microwave treatment units can treat most infectious waste generated at the hospital with the exception of radioactive waste, chemotherapy waste, human organs or body parts and mixed medical and hazardous waste. Microwave systems are designed to treat waste at a rate approaching 220 lb/hour. The waste is placed in a hopper and fed into a grinding chamber. These grinding processes reduce the volume of waste by approximately 80%. The ground waste is sprayed with steam to increase its moisture content and intensify the heating process.

Radio frequency irradiation is also an adaptation of an existing technology to the treatment of medical waste. In the short-wave radio frequency systems, the waste is shredded and compacted into large insulated polyethylene treatment containers. Conveyors are used to transfer the containers out of the processing room and into the

dielectric heating area. Low frequency radio waves (11 to 13 MHz) carry the electric energy, which are absorbed by the waste materials, heating them uniformly to at least 90 °C as the containers move slowly through the heating area. The heated waste is then stored in the insulated containers for a specified time after which it may be disposed of in a landfill.

2.6.5 Other Treatment Methods

2.6.5.1 Encapsulation

Encapsulation, is the cheapest and easiest way to dispose of sharps without the possibility of them being recovered by scavengers or injuring waste workers. Sharps are collected in puncture resistant and leak-proof containers. When a container is three quarters full an encapsulating media is poured into the container until it is full. Once the medium has dried, the boxes are sealed and may be disposed of to landfill.

Pharmaceutical waste, and small residues of chemical wastes, could be encapsulated in the same way. This system is simple, safe and does not require skilled labor to implement. But this system is not recommended for the infectious or pathological categories of health care waste. Also it requires the local availability of cement or other encapsulating medium and the sufficient funds to purchase these materials.

2.6.5.2 Continuous Feed Technology

Continuous feed technology is a relatively new technology. It involves shredding the medical waste, followed by passing it into a rotating archemedes screw. This carries the waste through a heated chamber. The screw is heated internally by

circulating hot oil. Disinfection (at 110 °C to 140 °C) is achieved by heat radiation into the waste. The technology is most suited for sharps and infectious, pathological, but not anatomical wastes and is reportedly a cheaper technology to procure and operate than incineration (WHO, 1997).

2.6.5.3 Gas Sterilization

Gas sterilization system involves the exposure of medical equipment to gas in a tight chamber, with the air evacuated. The gas used in this treatment is (ethylene oxide). This treatment is normally used for sterilizing equipment to be reused rather than for waste treatment. However, possible fugitive gas leaks might occur which might have carcinogenic effect to exposed workers. No volume or weight reduction is achieved by this treatment, and residues of toxic gases on the materials will be vented after treatment.

2.6.5.4 Grinding and Shredding

In this system the waste is converted to a homogenous form that is easy to handle, with no leakage, and no need for clipping devices to remove needles and syringes. The disadvantages are: small amount of waste, continuous maintenance, and the need for qualified operators.

2.7 DISPOSAL

The land disposal of medical waste without treatment may be considered provided that municipalities or other waste management establish realistic guidelines for a controlled landfill operation. This controlled operation involves the process of burying the waste on arrival under two meters of municipal waste. Microbial degradation

conditions also must be sufficient to degrade the waste and reduce the pathogen content. The disposal of untreated medical waste onto the surface of uncontrolled open dumps is considered wholly unacceptable. This is because the waste degradation conditions in open dumps are not suitable and the waste is open to scavengers (WHO, 1997).

2.7.1 Landfill Disposal

Landfill is the inevitable end point for all medical waste whether treated or not. If a waste treatment option is adopted, it should be accompanied by a parallel enhancement of all available land disposal sites. An improved standard of landfilling does not imply unrestricted open dumping. It is recommended that all medical waste, whether treated or not, should be buried at the base of a two-meter layer of municipal solid waste and isolated to prevent access by scavengers.

The Canadian Council of the Ministers of the Environment (1992), recommended several guidelines to be followed when handling decontaminated waste at landfill sites. Some of these guidelines are:

1. Generator of waste provides the landfill site operators with details of waste (i.e. nature of waste), quantity of waste, and time of delivery. This will provide the employee with the needed information to be aware of risk and health hazards.
2. Waste is to be buried immediately upon receipt.
3. Prevent direct contact with compaction equipment or other equipment operating at the surface, the waste is covered with either earth or noninfectious waste at the site.

4. Instructions and training are needed for employees on the correct way of handling and disposing of hazardous and infectious waste.

The recommendations for a well-run landfill as illustrated by Coad (1994), a specialized a landfill for hazardous medical waste and to allow close supervision of the operation. The waste is to be isolated by cover material of 500-mm thickness. This landfill site will not be used for other types of wastes.

2.7.2 Safe Burial On-Site

Safe burial on-site is an acceptable disposal technique in some lower income areas, particularly at medical institutions in remote locations or during emergency. The most practical solution to disposal of treated or untreated medical waste may be by placing the waste in a burial pit within the grounds of the institution. An illustration of a burial pit is illustrated in Fig. 2.2. This simple disposal option can be applied provided that the location is in a restricted area. Nevertheless, it is expected that some hazards are linked to the burying of infectious waste. These hazards are potential underground water contamination, soil contamination and direct infection of scavengers. These systems are less hazardous than allowing the waste to be unprotected and accessible. On-site burial is relatively safe if access is restricted and the site is selected and prepared to prevent soil contamination. However, restricted access may not be guaranteed at all time. Furthermore, it may be difficult to assess the conditions for safe sites and the risk of sub-surface pollution remains.

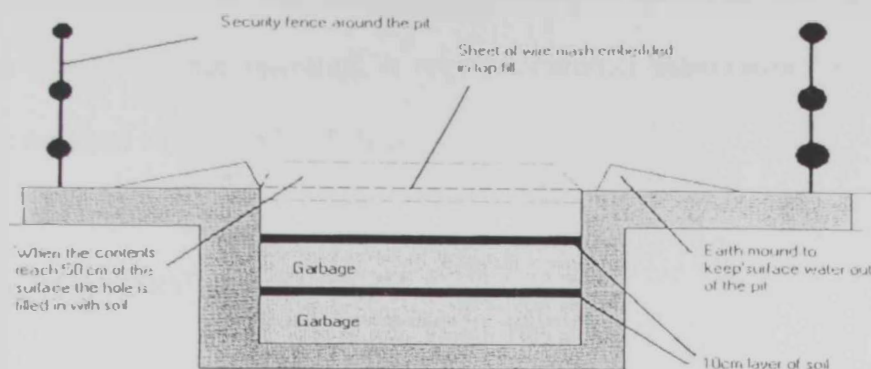


Fig. 2.2 Safe burial of medical waste on site.

2.7.3 Wastewater Disposal to Sewers

The direct discharge of untreated wastewater from a medical institution into nearby streams and lakes is unhygienic, unsafe and should be unacceptable to the management of the institution. There are a wide variety of wastewater disposal technologies available for areas not connected to a sewer system including surface lagoons and septic tanks.

A lagooning system may comprise of two successive lagoons through which the wastewater is retained, initially in the first lagoon, before passing on to the second in order to achieve an acceptable level of purification. The system may eventually be followed by land infiltration of the effluent to benefit from the soil filtering capacity. Alternatively, unsewered medical centers may establish underground concrete chambers (septic tanks) to receive all waste. Solids in the tank settle to the bottom and become anaerobically digested. Floating scum rises to the surface and free liquid

remains in the middle regions and passes out of the tank into a soak away area. The low concentration of organic compounds in the free liquid are further decomposed aerobically in the surrounding unsaturated soil. Skilled labors are needed to construct a septic tank, but once operating it requires minimal maintenance except for the periodic removal of accumulated sludge.

2.8 REGULATORY FRAMEWORK

Several international initiatives on waste management have been outlined in recent years to assist countries to improve the thoroughness of their national laws and to establish enforceable regulations. The basic principles incorporated into new waste policies include waste hierarchy, legal principles, legislation, policy guidelines, and technical guidelines. These principles as outlined by the WHO (1997) are briefly discussed below.

2.8.1 Waste Hierarchy

Agenda 21 was adopted as an action plan of work in 1992, during the United Nations Conference for sustainable development and recommended measures for waste management (Fig 2.3). The relevance of Agenda 21 (WHO, 1997) to medical waste management could be faced, however, with some practical limitations. First, the scope of minimizing medical waste lies mainly with the non-risk wastes (glass, paper, metals). Second, minimization initiatives for the risk waste is more restricted due to the fears of handling and recycling contaminated items. Third, the use of incineration and other treatment processes could be expensive to some middle and

low income areas to keep them operational. In these areas, land disposal may well be the most practical, sustainable option.

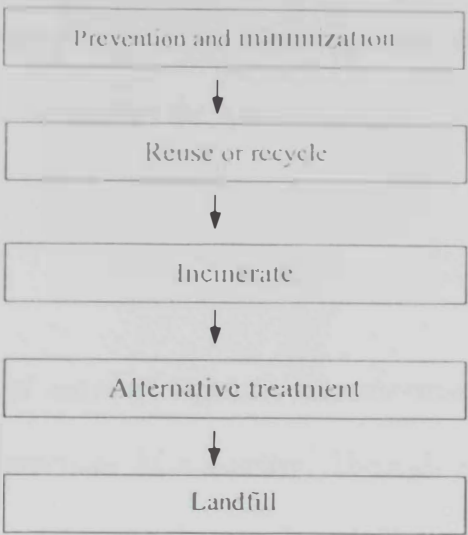


Fig. 2.3 Hierarchy of waste management

2.8.2 Legal Principles

Legal principles in waste management are established to minimize the health risk associated with the handling, transport, treatment, and disposal of generated wastes. There are five guiding principles in waste laws: 1) The “Polluter-pays” Principle implies that waste producers are legally and financially responsible for the safe disposal of their waste; 2) the “Precautionary” Principle is intended to increase public health by assuming a significant risk associated with wastes that are suspected to be serious, but not accurately known; 3) the “Duty-of-care” Principle recognizes that any person or organization managing medical waste or related equipment is ethically responsible for applying the utmost care while the waste is under their responsibility; 4) the “Proximity” Principle recommends that treatment and disposal

applicable to offenders and the inspection system to ensure compliance with the law, and 5) designation of legal courts empowered to settle disputes resulting from the enforcement or non-compliance with the law.

Operating a medical institution and an on-site facility for the disposal of medical waste should also comply with other national legislation related to environmental and health impact assessment, air and water quality, prevention and control of infectious diseases, public health laws, and management of chemicals and radioactive materials.

2.8.4 Policy and Technical Guidelines

These guidelines provide information for the proper treatment of wastes from public and private health-care establishments. The provided information constitutes due consideration of the waste management requirements of disposal and recovery measures as well as the requirements of hygiene. Policy documents on medical waste management should be established. These documents should outline the rationale, goals, and steps to achieve improvement in the proper management of medical waste. This requires the establishment of technical guidelines that should be practical and applicable.

2.9 RADIOACTIVE WASTE PRODUCED AT HOSPITALS

Radioactive waste in general is produced from several sources including the normal operation and maintenance of nuclear power plants, industrial applications as

well as the utilization of radioactive isotopes in hospitals and research institutes. Various methods of disposal and containment are used to manage this type of waste.

Special procedures are utilized to permanently dispose of low-level radioactive wastes produced at hospitals. In certain cases, the radioactive material is returned to the supplier. The most common disposal method, however, is to use physiochemical processes for immobilization of the radionuclides in the waste with maximum volume reduction (Tzeng et al., 1998). Such treatment usually requires pretreatment steps to separate the wastes into combustibles, non-combustibles, and metals. Combustible materials are normally incinerated, with the ash then being mixed with cement and stored in containers. Non-combustible materials are either compacted or directly converted into a solid matrix. Metals are melted and cast into containers.

Existing process technologies for disposal of low-level radioactive waste have two main disadvantages (Tzeng et al., 1998): 1) different types of waste have to be separated, manipulated and treated with different equipment; and 2) volume reduction and vitrification are not achieved within one step.

Special care is needed when handling and discarding old equipment containing radioactive sources. The discarding of radioactive hospital equipment in one Brazilian city caused a notorious accident in 1989, as reported by the international media (Code, 1994). At least 244 people had measurable contamination of cesium chloride on or in their bodies, with twenty of them being seriously radiated. Ten of the twenty had extensive decontamination and radiation-damage treatment. There were many

other fatal and serious cases of irradiation from radioactive hospital waste discarded in abandoned equipment scavenged from landfills and dump yards (Code, 1994).

In general, radioactive waste from medical establishments has a fairly low level of radioactivity and a short half-life (Code, 1994). A normal procedure for handling these materials is to store the waste under carefully controlled conditions until the level of radioactivity is so low that they may be treated as other wastes. A review of the management of radioactive wastes in medical institutes has been conducted by Sztanyik (1993). The study revealed that most radionuclides used in medicine are short-lived beta-, or beta-gamma emitters and represent a low risk, if properly handled. Sztanyik (1993) stated that low activity gaseous and liquid waste can usually be discharged to the environment directly, whereas medium activity or high-activity waste should be stored for variable periods to allow natural decay before specialized disposal.

2.9.1 Sources and Characteristics

Radionuclides are used in hospitals for diagnostic, therapeutic, and research purposes (Table 2.8). The use of radionuclides for diagnostic purposes has both “in vitro” and “in vivo” applications. In vitro applications typically involve the utilization of sterilized, aqueous-based radionuclides to measure levels of drugs or hormones in biological samples. Some radionuclides are used to label human blood components acting as a tracer for the identification of sites of blood loss, or sites of infection. This typically involves taking blood samples, radiolabeling and re-injection. Radioactive gases and aerosols are also used for diagnostic purposes for lung ventilation imaging (Efremenkova, 1997). Therapeutic application of radionuclides in medicine utilizes a

number of unsealed containers (open source which is usually directly applied and not encapsulated during its use), with higher activity than those used in diagnosis. In this case, individual patient doses are in the range of 200 MBq to 11.1 GBq.

Table 2.8 Sealed sources used in medicine and research (Efremenkov, 1997).

Application	Radionuclide	Half-life	Source activity ^a	Comments
Bone densitometry	²⁴¹ Am	433.0 yr	1-10 GBq	Mobile units
	¹⁵³ Gd	244.0 d	1-40 GBq	
	¹²⁵ I	60.1 d	1-10 GBq	
	²³⁹ PI\Be			
Manual brachytherapy	¹⁹⁸ Au	2.7 d	50-500 MBq	Small portable sources
	¹³⁷ Cs	30.0 yr	30-300MBq	
	²²⁶ Ra ^b	1600 yr	50-500 MBq	
	⁶⁰ Co	5.3 yr	50-1500 MBq	
	⁹⁰ Sr	29.1 yr	50-1500 MBq	
	¹⁰³ Pd	17.0 yr	50-1500 MBq	
	¹²⁵ I	60.1 d	200-1500 MBq	
	¹²⁹ Ir	74.0 d		
	¹⁰⁶ Ru	1.01 yr		
Remote after loading brachytherapy	¹³⁷ Cs	30.0 yr	0.03-10 MBq	Mobile units
	¹⁹² Ir	74.0 d	200 TBq	
	⁶⁰ Co	5.3 yr		
Teletherapy	⁶⁰ Co	5.3 yr	50-1000 TBq	Fixed installations
	¹³⁷ Cs	30.0 yr	500 TBq	
Whole blood irradiation	¹³⁷ Cs	30.0 yr	2-100 TBq	Fixed installations
	⁶⁰ Co	5.3 yr	50-1000TBq	
Research	⁶⁰ Co	5.3 yr	Up to 750 TBq	Fixed installations
	¹³⁷ Cs	30.0 yr	Up to 13 TBq	
Calibration and anatomical markers Sources as standards for used instruments	⁶³ Ni	96 yr	<4MBq	Fixed installations In instruments or mobile sources
	¹³⁷ Cs	30.0 yr	<4MBq	
	⁵⁷ Co	271.7 d	Up to 400MBq	
	²²⁶ Ra ^b	1.6x10 ³ yr	<10MBq	
	¹⁴⁷ Pm	2.62 yr	<4MBq	
	³⁶ Cl	3.01x10 ⁵ yr	<4MBq	
	¹²⁹ I	1.57x10 ⁷ yr	<4MBq	

^aG = giga = 10⁹, M=million, T=trillion, Bq=Bequerel=cs⁻¹

^bRadium are not generally used for therapeutic treatment but exist as spent sources in hospitals.

In medical research, the range of radionuclides used is much wider than the one used for in vitro and in vivo diagnostic/ therapeutic purposes. The reason for this is that radionuclides are often evaluated for several years in animal studies at

pharmaceutical research establishments prior to the granting of a license to verify that the product is safe for human administration. Approved sealed sources are used in a wide range of activities for therapeutic purposes, bone densitometry, anatomical marking and calibration. Many are directly implanted or applied to a patient including the use of ruthenium for eye plaques, and the use of ^{192}Ir , ^{137}Cs , and ^{198}Au for implants. A number of different sealed radiation sources are used for medical treatment in manual brachytherapy, teletherapy, and blood irradiation (Table 2.9).

2.9.2 TYPES OF MEDICAL RADIOACTIVE WASTE

Medical radioactive waste may be defined as radioactive waste arising from diagnostic, therapeutic and research applications in medicine. The amount and types of waste vary depending on the range of medical activities and radionuclide involved. Medical radioactive waste is sometimes classified according to its physical, biological or chemical characteristics.

Medical radioactive waste can be liquid or solid in its physical state. The hazards associated with the liquid medical radioactive waste could be biological (from urine, blood, wound discharges), chemical (from solvent) or toxic (from monoclonal antibodies as chemotherapy agents). Solid waste is typically classified as combustible/noncombustible and compatible/non-compatible. It generally contains relatively low levels of radioactivity when compared to liquid wastes. Examples of solid radioactive wastes generated at hospitals include (Efremenkova, 1997):

- Spent radionuclide generators.

**Table 2.9 Principle radionuclides used in medicine and biological research
(Efremkov, 1997).**

Isotope	Half-life	Principle application	Typical quantity per application	Waste characteristics
³ H	12.3y	Radiolabelling Biological Research Organic Synthesis	Up to 50 GBq	Solvents, solid liquid
¹⁴ C	5730y	Medical Biological research Labeling	Less than 1 MBq Up to 50 GBq Up to 50 GBq	Exhaled CO ₂ Solid, liquid solvent
¹⁸ F	1.8h	Positron emission Tomography	Up to 500 MBq	Solid, liquid
²⁴ Na	15.0h	Biological research	Up to 5 GBq	Liquid effluent
³² P	14d	Clinical therapy	Up to 200 MBq	Solid, liquid
³³ P	25.4d	Biological research	Up to 50 MBq	effluent
³⁵ S	87.4d	Medical Biological research	Up to 5 GBq	Solid, Liquid effluent
³⁶ Cl	3.×10 ⁵ y	Biological research	Up to 5 MBq	Gaseous Solid, liquid
⁴⁵ Ca	163d	Biological research	Up to 100 MBq	Mainly Solid, some liquid
⁴⁶ Sc	83.8d	Medical and biological research	Up to 500 MBq	solid, liquid
⁵¹ Cr	27.7d	Clinical measurement Biological research	Up to 5 MBq Up to 100 MBq	solid mainly liquid effluent
⁵⁷ Co	271.7d	Clinical measurements	Up to 50 MBq	Solid, liquid
⁵⁸ Co	70.8d	Biological research		effluent
⁵⁹ Fe	44.5d	Clinical measurements Biological research	Up to 50 MBq	Solid mainly liquid effluent
⁶⁷ Ga	3.3d	Clinical measurements	Up to 200 GBq	Solid, liquid effluent
⁷⁵ Se	172d	Clinical measurements	Up to 10 MBq	Solid, liquid
^{81m} Kr	13.3s	Lung ventilation studies	Up to 6 GBq	Gaseous
⁸⁵ Sr	64.8d	Biological research	Up to 50 MBq	Solid, liquid
⁸⁶ Rb	18.7d	Medical and biological research	Up to 50 MBq	Solid, liquid
^{82m} Rb	6.2 h	Clinical measurement		Solid, liquid
⁸⁹ Sr	50.5d	Clinical therapy	Up to 300 MBq	Solid, liquid
⁹⁰ Y	2.7d	Clinical therapy Medical and biological research	Up to 300 MBq	Solid, liquid
⁹⁵ Nb	35.0d	Medical and biological research	Up to 50 MBq	Solid, liquid
^{99m} Tc	6.0h	Clinical measurements biological Diagnostic	Up to 100 MBq	Solid, liquid
¹¹¹ In	2.8d	Clinical measurements Biological research Diagnostic	Up to 50 MBq	Solid, liquid
¹²³ I	13.2h	Medical and Biological research	Up to 500 MBq	Solid, liquid
¹²⁵ I	60.1d	Diagnostic		● occasionally vapour
¹³¹ I	8.0d	Clinical measurements Clinical therapy		
¹¹³ Sn	155d	Clinical measurements	Up to 50 GBq	Solid, liquid
¹³³ Xe	5.3d	Clinical measurements	Up to 400 GBq	Gaseous, solid
¹⁵³ Sm	1.9d	Clinical therapy	Up to 8GBq	Solid, liquid
¹⁶⁹ Er	9.4d	Clinical therapy	Up to 500 MBq	Solid, liquid
¹⁹⁸ Au	2.7d	Clinical measurements		
²⁰¹ Tl	3.0d	Clinical measurements	Up to 200 MBq	Solid, liquid
²⁰³ Hg	46.6d	Biological	Up to MBq	Solid, liquid

- Fragments from sources used in brachytherapy.
- Excreta from patients administered with radionuclides for diagnostic, therapeutic and research purposes
- Anatomical wastes including body parts, tissues and organs
- Ancillary wastes including materials which may have come into contact with humans or animals, protective clothing, plastic sheets and bags, gloves, masks, filters, overshoes, paper wipes, towels, metal and glass, infectious waste, hand tools, and discarded equipment.
- Resin columns, matrix gels, and chromatography plates from medical diagnostic and research.
- Miscellaneous wastes which pose a puncture hazard.
- Food waste from patients administered with radionuclides for therapeutic purposes as in the case of ^{131}I -ablation therapy.
- Filters used in equipment including charcoal traps and fumed filters.

2.9.3 Waste Management Strategies

A medical radioactive waste management strategy is normally developed that best fits the local needs and circumstances that meanwhile demonstrates regulatory compliance. Collection, handling, segregation and packaging of medical radioactive waste utilize not only the same practice used for managing any radioactive waste but should also include practices to control any biohazards waste component.

There are possibly two strategies for managing radioactive medical waste: on-site strategy or a combination of on-site and a centralized strategy (Tzeng et al, 1998). An on-site strategy would be advantageous for the vast majority of short half-life

radionuclides used in medicine. The second option would be recommended as a cost-effective way of treating long half-life medical radioactive waste, which is contaminated with hazardous chemicals. In either strategy, control by the regulatory body is required and must be maintained.

Practices and concepts of a waste management strategy for medical radioactive waste may vary considerably from one country to another. The actual on-site strategy for handling medical radioactive waste may be determined by the needs to dispose of the non-radioactive biohazards waste. According to Efremenkova (1997) the following basic principles are to be considered carefully when developing such a strategy:

- Only proven technologies are to be considered and these must be relevant to the types and characteristics of generated medical radioactive waste.
- The technologies and the entire waste management system are to be applicable to the conditions prevailing in the country. This includes legal and regulatory structure as well as economic, social, and physical conditions.
- An integrated approach with application of the “As Low As Reasonably Achievable” principle is to be followed. This requires consideration of the entire sequence of waste management operations from waste arising to waste collection to final disposal, and all related issues such as production, packaging, conditioning, storage and preparation for transportation.
- The overall development of a waste management strategy is not a static process. It should be subject to periodic review, at least annually, to ensure optimization of waste management practices and continued compliance with regulatory requirements.

2.9.4 Waste Collection and Segregation

In contrast to other nuclear applications, the use of radionuclide in medicine nearly always involves only one radionuclide being used per procedure. This makes segregation of waste by individual radionuclide very practical. Collection is usually carried out in special containers suitable for such waste, taking into consideration the physical, chemical, biological and radioactive properties of the waste. Waste bags/containers are partially filled in a way that their integrity is not compromised.

In most instances, it is convenient to segregate medical radioactive waste at the point of generation according to their half-life. Liquid radioactive waste are collected, segregated and characterized away from the point of origin according to its physical, chemical, biological properties. Chemically incompatible wastes are collected separately to avoid chemical reactions. Biologically contaminated radioactive liquid wastes are to be collected separately and sterilized using common procedures (i.e. autoclaving or chemical disinfection) after waste deactivation.

Collection of solid medical radioactive wastes normally involves distribution of suitable containers throughout the working area to receive discarded radioactive materials. Containers should be lined with primary packaging, such as a heavy-duty plastic bag and clearly displayed with the radiation symbol so as to distinguish them from bins for inactive wastes. It is advisable to have several types of containers for segregation of the different types of solid medical radioactive wastes at the time and place of production. Due to the biological hazard of these radioactive wastes, containers with covers are used for their collection.

Waste collections are usually scheduled so that biohazardous materials do not deteriorate in the refuse bins. Special consideration is always given to the management of contaminated sharp objects, such as needles and syringes, scalped blades, blood lancets, glass ampoules, etc

2.9.5 On-Site Storage

On-site interim storage of medical radioactive waste may be necessary for different reasons including waste deactivation, storage prior to pretreatment/treatment, or storage prior to returning to vendor. Although the safety requirements in the case of temporary storage may be less stringent than for long term storage, nevertheless adequate attention should be paid to the needs of shielding and preventing leakage as well as to the specific requirements of chemical and biological components of waste (freezing, refrigeration, ventilation, etc). The design of the storage facility for unconditioned radioactive waste should reflect government guidance and regulations.

Storage locations used for the purpose of holding medical radioactive wastes are to be illuminated and appropriately ventilated. They should be physically isolated, appropriately labeled outside, and well protected against unauthorized human intrusion. Furthermore, storage area should have sufficient holding capacity that reasonably reflects its expected inventory. The storage area should be impervious, with well-drained flooring and equipped with protective equipment and materials for dealing with spills as well as having appropriate monitoring devices.

Deactivation storage is a very efficient, and an economic waste management procedure for medical radioactive wastes, since many of the used radioactive materials are of short half-lives and the activity of the contaminated waste is well defined. Practical experience has shown that decay storage is suitable for wastes contaminated by radionuclides with half-life of a hundred days (Efremenko, 1997). When large volumes of medical radioactive wastes are produced, it may be more convenient to partition the short-term decay storage facility to provide areas for storage of wastes according to their half-lives. A normal decay storage period of ten half-lives will reduce the initial radioactivity to less than one thousandth of its original radioactivity. In many cases, such storage will achieve deactivation level below the clearance levels for safe release depending on the local regulatory requirements.

Decay storage to clearance levels is typically preferred both scientifically and economically. Subsequent disposal of waste as municipal refuse requires accurate administrative control measures and careful waste segregation and activity measurement, both at the origin of waste production and at the end of the decay storage period.

In circumstances where generated waste has a half-life of greater than a hundred days it may be routed to a centralized waste processing and/or disposal facility. The original packaging in which such wastes are accumulated and the segregation methods used must reflect the acceptance requirements of the centralized facility and any subsequent treatment the waste will be subjected to prior to longer-term storage.

2.9.6 Waste Pretreatment

In many countries, hospitals process their radioactive wastes on site, tending only to use a centralized facility for disposal of spent sealed sources. Some of this pretreatment may be utilized before the waste is sent for further treatment, usually by incineration, or before disposal/discharge.

Some medical radioactive wastes require storage in freezer cabinets or chilled rooms in order to prevent putrefaction. Chilled rooms are only likely to be required where prolonged periods of storage are necessary or the volume of waste produced is large. For smaller volumes and shorter storage times, freezer cabinets are adequate, as they are more economical to purchase, operate, and maintain.

Use of appropriate packaging is an essential component of the radioactive waste management system. The selection of proper packaging materials, package style, and the amount of packaging are necessary to minimize waste volume. Proper packaging also provides reliable containment during storage, facilitates handling and simplifies subsequent waste treatments. The type of package normally corresponds to the character and type of waste (biological, sharps, liquids, etc).

Liquid waste is collected in suitable containers or tanks selected according to their chemical and radiological characteristics, the volume of the waste, and the handling and storage requirements. In general, polyethylene containers are used in preference to glass, as they are more robust and can be easily and safely volume-reduced when required. Often, storage containers are stored in additional containment

packing that is able to collect the contents of the primary storage vessel. Color-coded containers can be used for segregated waste stream and the color reference should be documented.

2.9.7 Treatment of Radioactive Medical Waste

Several processes and procedures are utilized in the treatment of radioactive medical waste. These processes can be categorized as mechanical, thermal, and chemical treatment. These procedures to a great extent are similar to the ones applied in the treatment of the general medical waste as discussed in Section 2.6 of this chapter.

CHAPTER 3

METHOD OF ASSESSMENT AND EXPERIMENTAL PROCEDURE FOR ASH ANALYSIS

3.1 SURVEYED HOSPITALS

Medical waste management in UAE was assessed through conducting a survey and an on-site visits to major hospitals in the country. The main purpose of the survey was to evaluate procedures for medical waste management, and to identify opportunities for improving waste collection, handling and disposal as well as setting targets for waste minimization and opportunities for recycling, and cost reduction.

Fourteen hospitals were selected in the survey. These hospitals are distributed among the 7 emirates as shown in Table 3.1. Five of the hospitals are located in Abu Dhabi Emirate, 4 in Dubai, and 1 hospital is located in each of the remaining emirates. Hospital selection was based on the number of beds available. The total number of beds in the selected hospitals is 4032, representing about 86% of the total number of beds in all the hospitals in the country. Among the 14 selected hospitals, 12 are funded by the government while the other two are private owned.

3.2 THE QUESTIONNAIRE

A questionnaire was distributed among the selected hospitals. The questionnaire was based on the format prepared in 1994 and 1997 by WHO/UNEP for

assessing medical waste management for the countries of West Asia and the Eastern Mediterranean. The questionnaire was modified so as to further expand the information pertaining to the treatment and disposal techniques of medical waste. The questionnaire consisted of eleven major questions, covering different aspects of waste management including legislation, waste handling, storage, pretreatment, treatment, and disposal. The questionnaire also addressed issues such as incinerator availability within the facility and the presence of pollution control equipment. Furthermore, the questionnaire tackled issues such as staff responsibilities, training and awareness. A copy of the questionnaire is presented in Appendix A.

Table 3.1 Hospitals included in the survey.

No.	Hospital	Emirate	Type	Beds	Occupancy (%)
1	Al-Mafraq	Abu Dhabi	Government	500	100
2	Al-Jazeira	Abu Dhabi	Government	350	90
3	Rashid	Dubai	Government	444	76
4	Dubai	Dubai	Government	524	63
5	Al-Kuwait	Dubai	Government	206	40
6	Tawam	Abu Dhabi	Government	320	86
7	Al-Ain	Abu Dhabi	Government	420	80
8	Al-Fujerah	Al-Fujerah	Government	178	60
9	Saqr	Ras Al Khaimah	Government	225	65
10	Um-Alqewain	Um-Alqewain	Government	166	45
11	Al-Qasimi	Sharja	Government	320	99
12	Shiekh Khalifa	Ajman	Government	219	75
13	Oasis	Al-Ain	Private	60	99
14	American	Dubai	Private	100	65
Total				4032	

In addition to the questionnaire, on-site visits were made to all selected hospitals where direct communication with personals in-charge were performed. The purpose of these visits was to observe the actual management practices in relation to procedures suggested by the Ministry of Health. Results of the questionnaire are presented in the Chapter 4.

3.3 EXPERIMENTAL ANALYSIS OF ASH SAMPLES

3.3.1 Activity of Ash Waste

Several hospitals indicated that incineration is used for the disposal of their radioactive materials after “decay”. In order to assess the effect of such disposal on the radioactivity of the incinerator ash content, it was decided to investigate the activity of incinerator ash. Ash samples were collected from seven hospitals for seven successive days. Four of these hospitals are using radionuclides. The other hospitals are not using radionuclides, which should determine the background level of activity. Two different detectors obtained from Tawam hospital were utilized to determine the activity of these samples: the Geiger-Muller tube (G-M tube), which is used to identify β -rays, and the scintillation instrument used to identify δ and β rays (Turner, 1995). A brief description of these analysis methods is presented below.

G-M Tubes are gas-filled detectors with high potential difference across the electrodes (Turner, 1995). Electrons approaching the anode will gain sufficient energy to produce further ionization. G-M tubes are very sensitive and are widely used to monitor low levels of radiation (Turner, 1995). However, G-M tubes provide no information about the nature of the radiation or the energies of individual radiation.

Scintillation was the first method used to detect ionizing radiation. When radiation loses energy in a luminescent material, it causes electronic transitions to excited states in the material (Turner, 1995). The most widely used scintillate is sodium iodide (NaI) which is sensitive to γ -rays and high-energy χ -rays. Other types

of scintillates include zinc sulfide (for α particles), lithium iodide (for thermal neutrons), and anthracene (for β and fast neutrons) (Turner, 1995)

To determine specific isotopes present in the ash waste, samples were collected from Tawam and Al-Ain hospitals during the months of November and December 2001. The samples were analyzed using gamma spectrometer at the Radiation Protection Department, Dubai. The gamma spectrometer used in measurements consisted of hyper pure germanium detector (Canberra model Ge 3018) with diameter 63 mm, length 39.5 mm and distance from the window of 5 mm. The electrical characteristic depletion voltage was +1800 dc volt. An emulation software was used to convert to a full featured multichannel analyzer (MCA). The detection efficiency was determined using the Marinelli Beaker standard source 429.

Two samples were collected from Tawam hospital (denoted T1 and T2) and three from Al-Ain hospital (A1, A2, and A3) during November. All these samples were tested individually. Furthermore, samples were collected from each hospital on six successive days during December. The six samples were combined in one sample representing ash waste produced during that month at each hospital (T3 and A4).

3.3.2 Metal Content

Ash samples were collected from all surveyed hospitals that incinerate their medical waste. These hospitals include Tawam, Al Ain, Al Qasimi, Al Fujerah, Shiekh Khalifa, Saqr, and Um- Al qewain. Ash samples were collected for seven successive days (from 12 to 18 May, 2001), from each hospital. Bulky objects in the waste samples were excluded before analyzing the samples for metal content. The

seven samples collected from each location were homogenized to obtain a representative sample of that location. Each homogenized sample was then split into three samples for reproducibility.

Ash samples were analyzed for total extractable metals and for leachable metals. Target metals were Cd, Cr, Ni, Zn, Pb, Cu. Metal analysis was conducted at the Central Laboratory Unit (CLU) at the UAE University. Metals were analyzed by Inductively Coupled Plasma (ICP) spectrometry using a Varian-Vista MPX CCD Simultaneous ICP-ES. Operating conditions of the ICP instrument include plasma flow of 15 L/min, auxiliary flow of 1.5 L/min, and a nebulizer flow of 0.75 L/min.

Total extractable metals from the ash samples were determined by the acid-digestion technique method number EPA 3051A (US EPA, 1983). A 1-gm portion of each ash sample was placed in a glass beaker and a 25-30 ml of Aqua Regia mix (HCl/HNO_3 at 3:1) was then added. The beaker was heated on a hot plate. Digested sample was then filtered and diluted to 100 ml before metal analysis.

Leachable metals were determined by the Toxicity Characteristic Leaching Procedure (TCLP) test. This test is designed to determine the mobility of both organic and inorganic analyses present in a certain waste. Experimental procedure used in conducting the TCLP test is schematically shown in Fig. 3.1. For all the tested samples, fluid 2 was used since the pH of the solution was greater than 5.0. The TCLP test requires the use of 100-g portion of the waste sample with 2 liters of the selected fluid. In this study, the solid/water ratio was maintained (i.e. 1:20) but a 20-g portion of the sample with 0.4 liters of fluid was used instead.

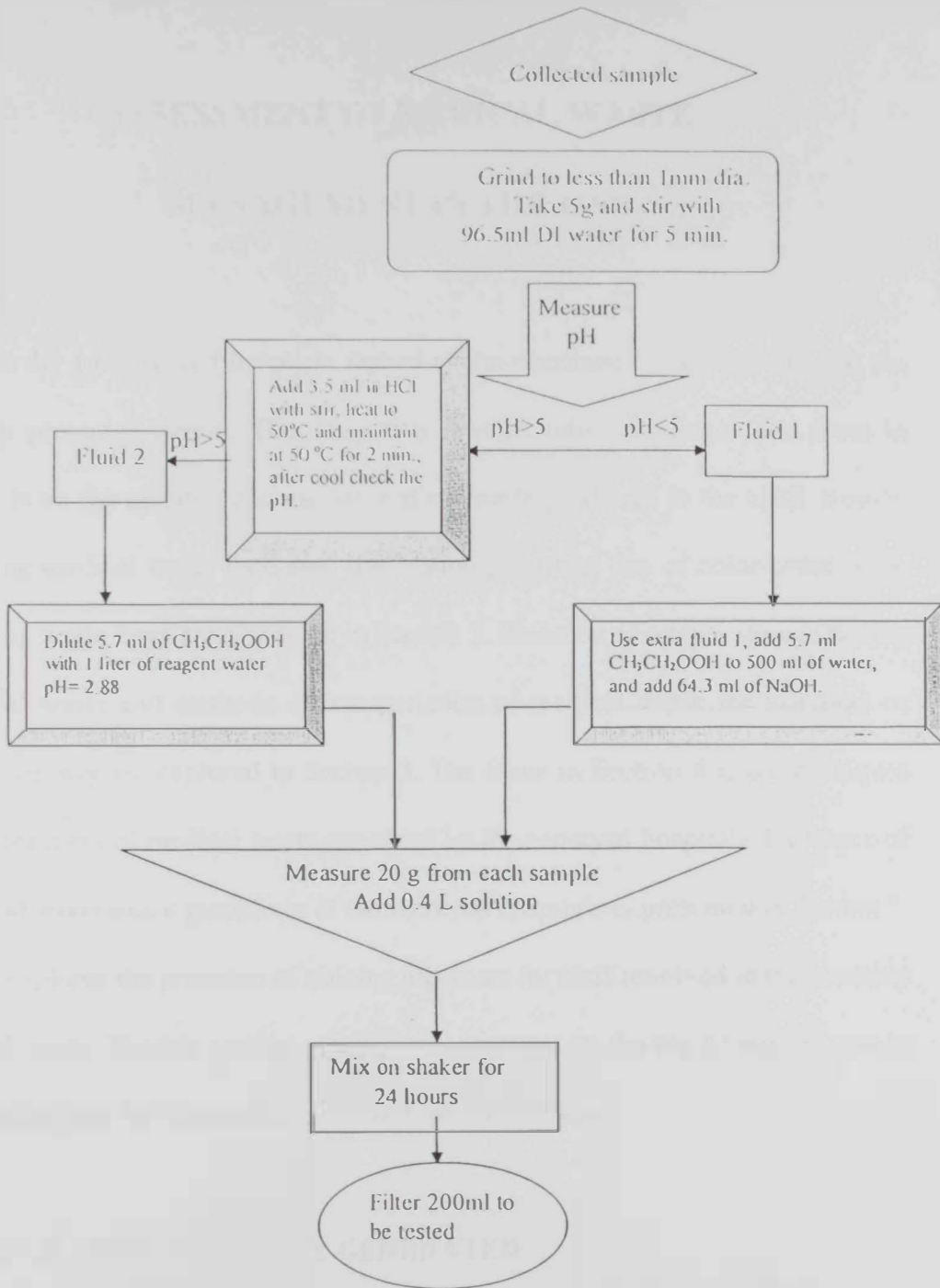


Fig. 3.1 Schematic diagram of the procedure of the TCLP test.

CHAPTER 4

ASSESSMENT OF MEDICAL WASTE

MANAGEMENT IN THE UAE

All the 14 surveyed hospitals replied to the distributed questionnaire and the results are presented herein. This chapter is divided into 7 sections. The focus in Section 1 is on the quantity and rate of medical waste produced in the UAE. Results on handling medical waste including segregation practices, use of color-coded bags, and labeling waste bags are presented in Section 2. Presence of on-site storage facility for medical waste and methods of transportation of medical waste for treatment or disposal purposes are explored in Section 3. The focus in Section 4 is on techniques used for treatment of medical waste generated by the surveyed hospitals. Existence of internal and government guidelines at the surveyed hospitals is presented in Section 5. Section 6 explores the presence of training programs for staff involved in the handling of medical waste. The last section of this chapter focuses on the use of radioisotope in UAE hospitals and the disposal of generated radioactive waste.

4.1 RATE OF MEDICAL WASTE GENERATED

Table 4.1 shows the amount of medical waste produced at each of the selected hospitals and the number of beds occupied per year. From this information, the rate of medical waste generated (kg per bed per day or per year) was calculated as listed in the table. It is to be noted that the daily amount of medical waste generated in kilograms varies from one hospital to another. This would be expected since the

number of beds is different among the various hospitals. However, the rate of medical waste produced when normalized to the number of beds at each hospital also varies and ranges between 0.2 to 4.5 kg/bed/day. The large differences in the rate of medical waste generated at the different hospitals, which reached more than an order of magnitude, was puzzling at first. However, it was noticed that some of these hospitals have expanded specialization, which will allow them to receive patients from each other for further treatment and to diversify their services. Another reason could be due to variation in the allocated hospital budget. These two factors could, to a certain extent, explain the large variations in the generation of medical waste between the major hospitals. Such results were also reported by other investigators in other countries (Liberti et al., 1996).

The average rate of medical waste generated per bed for all hospitals was calculated by dividing the total quantity of medical waste generated each day by the total number of beds occupied:

$$\text{Average rate} = \frac{\text{Total quantity}}{\sum \text{beds}} = \frac{6060 \text{ kg/day}}{3109.36 \text{ bed}} = 1.95 \text{ kg/day/bed}$$

The average rate obtained in this work (i.e. 1.95 kg/bed/day) is higher than the average rate reported by Shuwaiter (1994), which is 1.41 kg/bed/day. The higher rate of generation of medical waste reported in this study is possibly due to the way the numbers were determined. In this study, the actual number of occupied hospital beds were utilized in the determination of the rate, whereas in Shuwaiter's case the total number of beds in the hospital was used to obtain her data.

The total annual quantity of medical waste produced by the selected hospitals is about 2.2 million kg. Given that the selected hospitals represent about 86% of the total number of hospital beds in the country, it would be estimated that the amount of medical waste generated annually by UAE hospitals is about 2.6 million kg. The total amount would be higher since other medical care supporting facilities are not included in this study.

Table 4.1 Rate of medical waste generated at major hospitals in the UAE

No.	Hospital	Emirate	Beds	Occupancy %	Daily amount generated kg	Rate kg/bed/d
1	Al-Mafraq	Abu Dhabi	500	100	950	1.9
2	Al-Jazeera	Abu Dhabi	350	90	540	1.7
3	-- Rashid	Dubai	444	76	357	1.1
4	Dubai	Dubai	524	63	356	1.1
5	Al-Kuwait	Dubai	206	40	270	3.3
6	Tawam	Abu Dhabi	320	86	1250	4.5
7	Al-Ain	Abu Dhabi	420	80	500	1.5
8	Al-Fujerah	Al-Fujerah	178	60	60	0.6
9	Sagr	Ras Al Khaimah	225	65	30	0.2
10	Um-Alqewain	Um-Alqewain	166	45	40	0.5
11	Al-Qasimi	Sharja	320	99	1250	3.8
12	Shiekh Khalifa	Ajman	219	75	250	1.5
13	Oasis	Al-Ain	60	99	45	0.8
14	American	Dubai	100	65	162	2.5
Total			4032	-	6060	-

Comparison between the average rate of medical waste produced in the UAE, as reported here, with values reported for other countries (Table 2.3) reveals that the value is higher than that reported by other Gulf countries (i.e. Bahrain and Saudi Arabia) but typically lower than the values reported for Europe and the United States. The lower average rate of medical waste produced in UAE hospitals as compared to other countries could be due to the limited types of operations conducted at these hospitals. The lower value of medical waste generation rate may also be attributed to

the existence of other medical care supporting facilities in the UAE besides hospitals (Table 4.2) through which some waste will be produced that would have been accounted on the hospitals had these facilities not existed.

**Table 4.2 Medical establishments in the UAE as of 1999
(Annual Statistics Book, 1999).**

Emirate	Dental Clinic	PHCC ^a	SHC ^b	MCH ^c	Hospitals
Abu-Dhabi	40	50	222	52	16
Dubai	8	9	88	9	2
Sharja	7	13	119	11	5
Ajman	2	5	35	5	1
Um-Alqewain	3	5	24	3	1
Ras Al Khaimah	7	16	62	16	3
Al-Fujerah	5	7	35	6	2

^a Pediatric Health Care Clinic, ^b School Health Care, ^c Mother Care Hood.

4.2. HANDLING WASTE AT SOURCE

Proper handling of medical waste within an institution should be designed in such a manner that protects individuals who are exposed to this waste and facilitates efforts directed towards minimization, treatment and disposal of generated waste. In this section, the results obtained from the surveyed hospitals concerning segregation practices, the use of color-coded bags, marking on bags and containers, and an estimation of the amounts of medical waste components will be presented.

4.2.1 Segregation

As explained in Chapter 2, segregation is one of the important factors to manage in healthcare waste. Medical waste is usually segregated into risk and non-risk categories by sorting it into color-coded bags. Segregation of different types of

medical waste at the surveyed hospitals is summarized in Fig. 4.1. Details of the response on this question are presented in Table B.1, Appendix B. All the hospitals surveyed indicated that they apply segregation procedures for pathological, sharps, and infectious waste. However, not all hospital practice segregation of other types of medical waste including chemical, pharmaceutical, and pressurized containers. Three public hospitals among the 14 surveyed, i.e. Tawam, Al Kuwait and Saqr, practice segregation of all types of medical waste. The two private hospitals that were included in this study are also performing segregation of all types. Both chemical waste and pressurized containers receive the least segregation practice among the hospitals.

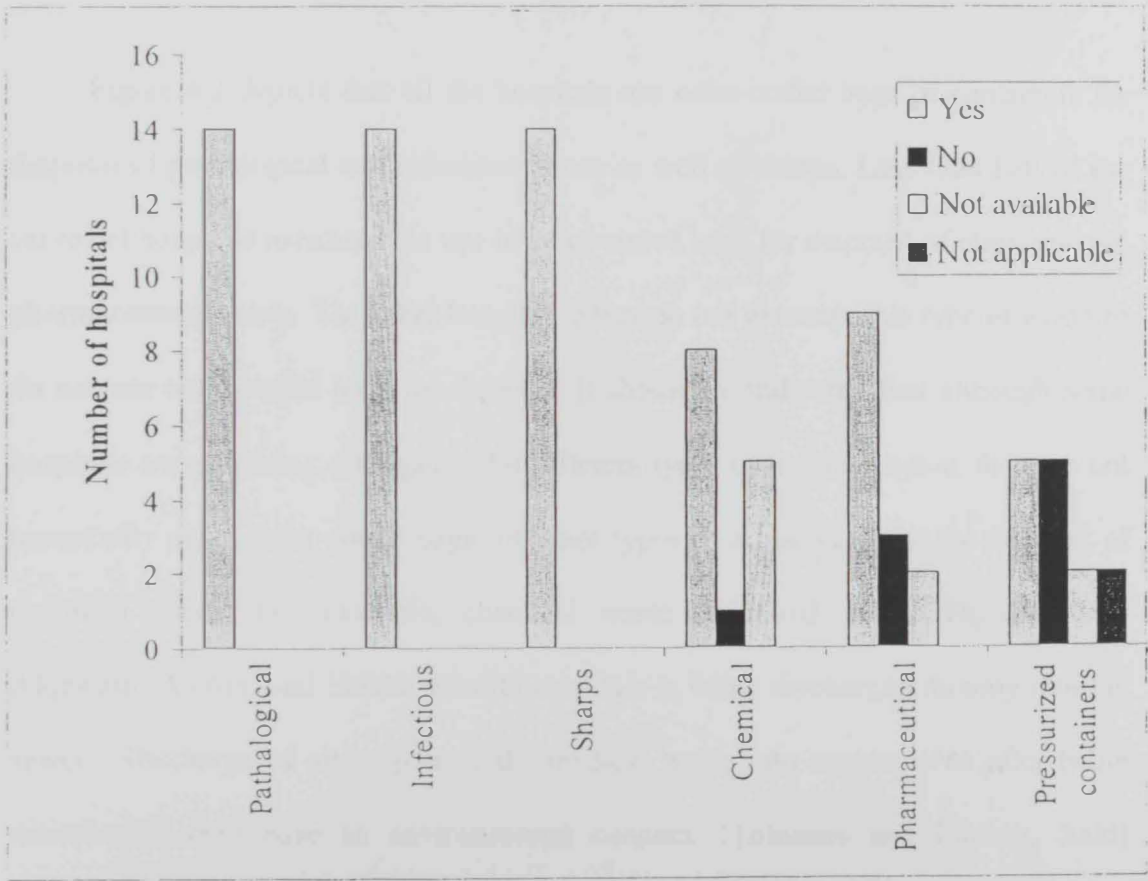


Fig. 4.1 Segregation of medical waste by type at 14 UAE hospitals.

4.2.2 Color-Coded Bags

Most of the UAE hospitals are using two color coded bags, black and yellow. Black bags are used for hospital waste that is not classified as a medical waste while yellow bags are used for medical waste. It is obvious that the UAE hospitals are not following the recommended procedure for segregation in terms of the use of the appropriate color-coded bags for different types of medical waste (WHO, 1994, UAE Ministry of Health, 1999). Despite of this, all the surveyed hospitals responded positively on the questions pertinent to the use of color-coded bags. Figure 4.2 shows the results on using color-coded bags for separation of different types of medical waste generated. Details of the responses to this question are presented in Table B.2 Appendix B.

Figure 4.2 depicts that all the hospitals use color-coded bags or containers for disposal of pathological and infectious waste as well as sharps. Less than half of the surveyed hospitals indicated the use of color-coded bags for disposal of chemical and pharmaceutical waste. The other hospitals either do not generate this type of waste or do not use color-coded bags for disposal. It should be indicated that although some hospitals are practicing segregation for different types of medical waste, they are not necessarily using color-coded bags for other types as is the case for the disposal of chemical waste. For example, chemical waste generated at Al Fujerah, Um-Alqewain, Al-Ain, and Shiekh Khalifa hospitals is being discharged directly into the sewer. Discharge of all or part of the medical waste into sewers even after being disinfected may pose an environmental concern. (Tolosana and Ehrlich, 2000) reported that outflows from Cape Town medical institutions contribute to the heavy

metal and toxic component which concentrates in the sludge at Athlone Wastewater Treatment Plant, and is discharged into rivers and the sea

Some hospitals responded positively on the use of color-coded bags for pressurized containers. Presence of pressurized containers in medical waste bags may cause serious problems if waste is to be incinerated.

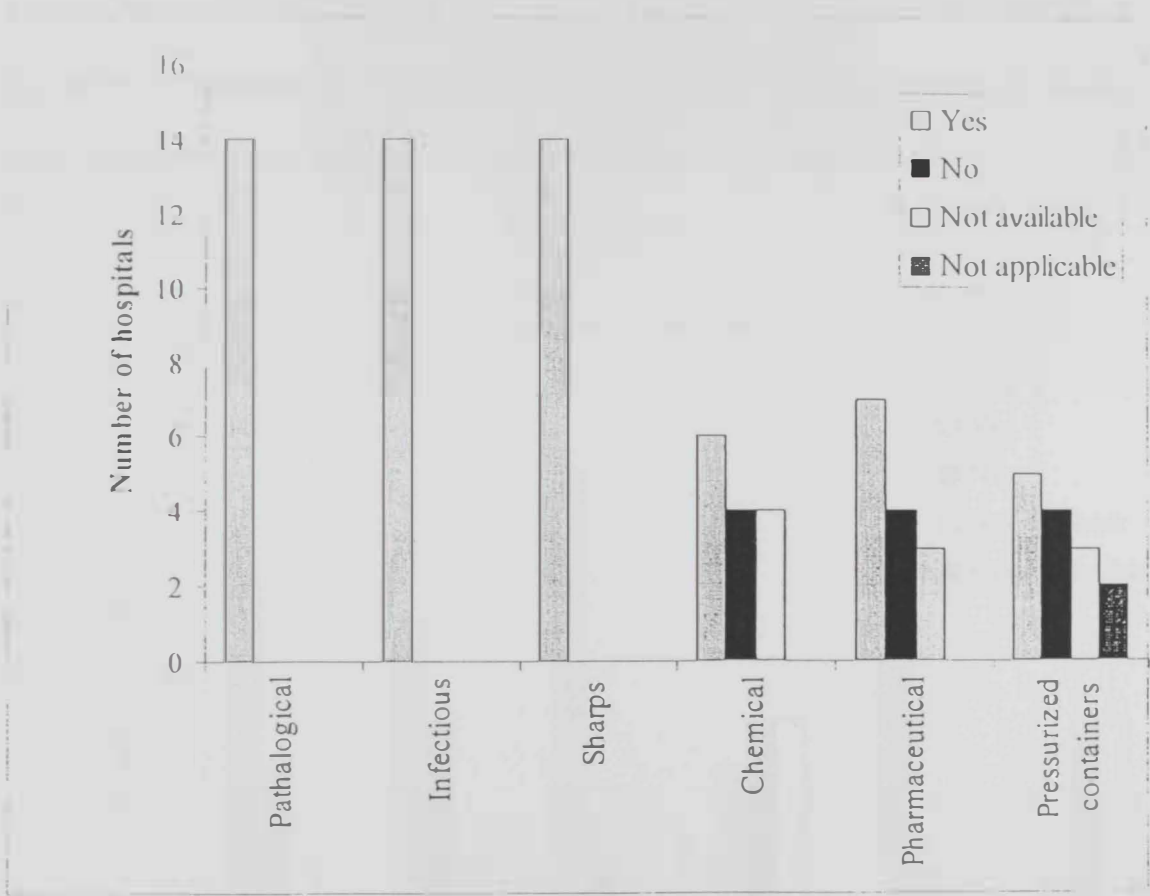


Fig. 4.2 Use of color-coded bags for different types of medical waste at UAE hospitals (N=14).

4.2.3 Labeling of Bags/Containers

The proper procedure for handling medical waste is to label each container and specify the originating department or source of such waste. All medical waste

generated leaving the storage areas are sealed and labeled, so that the source and quantity of the waste containers can be identified. This helps the housekeeping department to monitor and take proper action in case any problem occurs. The practice of marking on bags and containers at the UAE hospitals varies widely with some hospitals. Lawam, Rashid, Oasis, American, and Dubai, are practicing marking for all types of medical waste, while other hospitals, like Al Kuwait, Saqr, and Al Qasimi, do not practice marking for any type. Figure 4.3 summarizes the response of the surveyed hospitals on the question of labeling waste bags and containers. Details of the response on this question are presented in Table B.3 Appendix B.

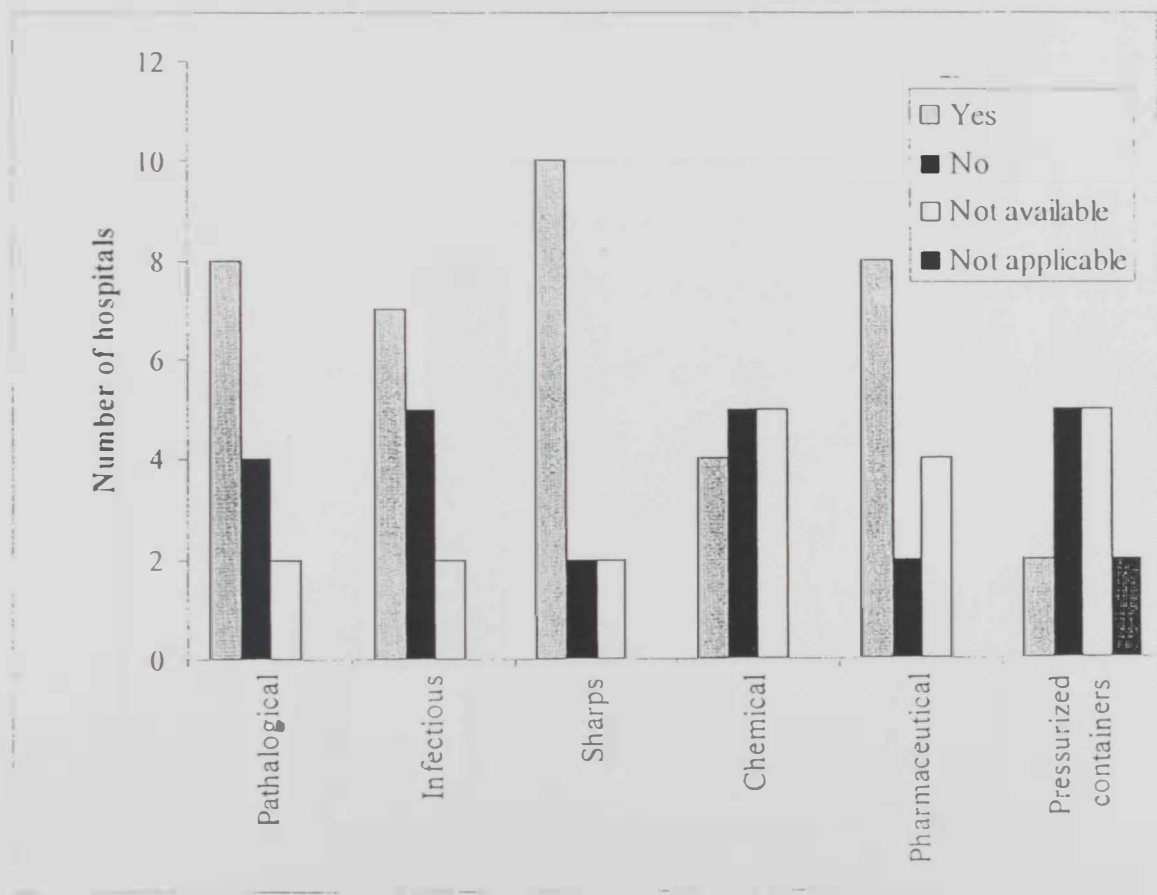


Fig. 4.3 Marking on bags and containers

4.2.4 Types of Medical Waste

Most hospitals in the UAE do not estimate the quantity of each type of the medical waste produced with the exception of Al-Mafraq, Oasis, and Shiekh Khalifa hospitals. Based on the information provided by Al Mafraq hospital, the distribution of each type of medical waste generated at the hospital is shown in Fig. 4.4. Infectious waste reaches about 84% of the total medical waste, indicating that laboratory waste associated with test procedures (i.e. cultures, stocks of infectious agents, and associated biological) is the predominate type of medical waste produced. Pathological waste, which is related to surgery or autopsy or other medical procedure and containers of body fluids, contributes up to 11% of the total medical waste. Sharps, chemical waste, and radioactive waste contribute to less than 6%.

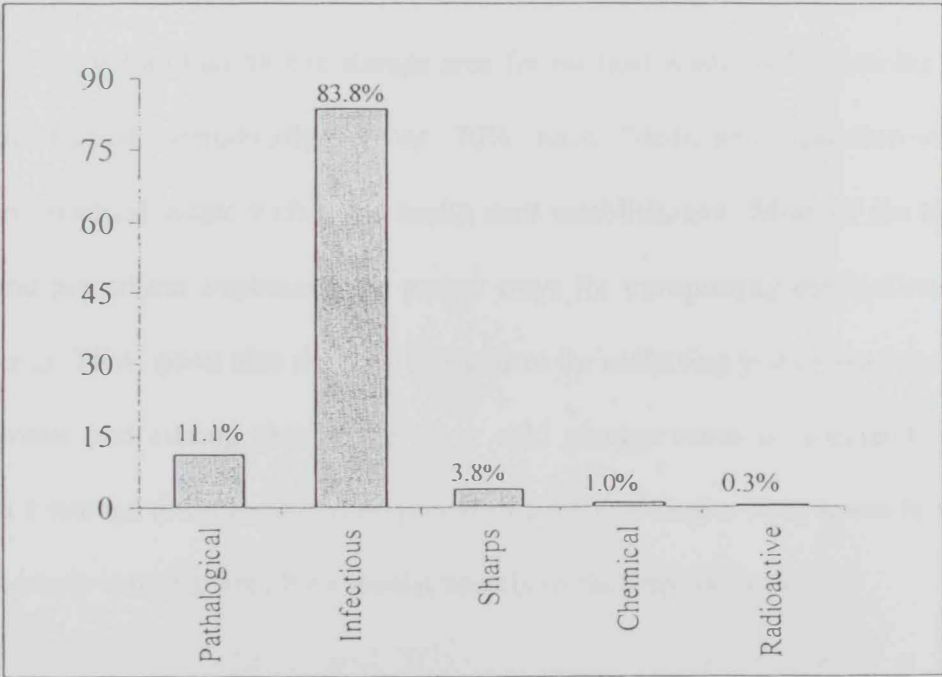


Fig. 4.4 Distribution of medical waste components at Al Mafraq Hospital

4.3 WASTE STORAGE AND TRANSPORTATION

Proper handling, segregation and storage of hospital waste requires the placement of instructions at each waste collection point in order to remind staff of the correct procedure. Containers are to be removed to a central storage point for subsequent treatment and disposal. WHO suggests that waste in the storage room is not to exceed the limit of three quarters full neither should be left for more than one day (WHO, 1997). As previously indicated (Chapter 2), separate central storage locations are to be designated inside the hospital. The storage location is to be a separate, locked room or building with access restricted to authorized individuals only.

Results of the survey conducted in this study revealed that about 70% of the hospitals included in the survey have a separate on-site storage area for medical waste. About 20% are without an on site storage area for medical waste, 64% have the storage facility disinfected periodically. About 70% have “dedicated” carts/vehicles for transporting medical waste within the health care establishment. Most of the hospitals have posted procedures explaining the proper ways for transporting medical waste and their disposal. These posts also describe procedures for collecting yellow bags containing medical waste and storing them either in a cold storage room or special temporary holding in a storage room for a certain period of time that ranges from hours to one day before the waste is transported by a special vehicle to the disposal area.

On-site visitation showed that most storage areas are open and without locks. In some cases, some of the waste bags were left in the open until being collected at the end of the day for treatment on-site or outside the premises. It was further noticed

that on-site incinerators at some hospitals are located quite a large distance from the source. In the absence of special vehicles or trolleys, workers placed the yellow bags inside a black bag to be dumped in dumpsters for municipal waste that are available in a close by vicinity. Inspection of a random domestic waste dumpster showed that this practice is not the exception, but a common practice. Boatright and Edwards (1995) reported that many healthcare facilities in the State of Oklahoma were disguising their "red" bags into domestic waste dumpsters so that the local collection and disposal process would not be interrupted or expensive alternative to local disposal required.

The absence of strong enforcement and control on handling and disposal of medical waste will encourage practice similar to the ones mentioned above. Other practices may as well be encouraged such as the illegal dumping at sites that are not authorized. An example of such an incident is what has been reported in December (2001) that the Irish Environmental Protection Agency discovered at least 487 sites (out of possible 2000 illegal dump sites) where hazardous materials including medical waste and toxic substances are thought to be buried (Birchard, 2002).

4.4 PRETREATMENT AND TREATMENT OF WASTE

4.4.1 Waste Pretreatment

The purpose of medical waste pretreatment is to reduce the pathogen content in the medical waste. This process commonly requires high temperature to be maintained for periods of up to an hour. There are several types of pretreatment methods that can be applied including microwave, autoclave, gas/vapor, and irradiation or chemical disinfection for liquid.

Most of the hospitals in UAE do not have pretreatment capabilities, possibly due to budget constraints or due to the wide use of disposable items. Microwave, gas/vapor, and irradiation are not used in any of the surveyed hospitals. However, autoclave is being used at Al Kuwait hospital for pretreatment of infectious and pathological wastes and at the American Hospital for the pathological waste. Chemical disinfection is used in few hospitals including Al-Am and Al Fujerah hospitals for pretreatment of pathological and infectious wastes.

4.4.2 Waste Treatment

Incineration system enables combustion of most categories of medical waste and destruction of the pathogens. Most UAE hospitals were using this kind of treatment (Table 4.3). Concern from toxic gaseous emission has been raised throughout the Emirates. Major hospitals such as Al Mafraq, Al Jazeera, Dubai, American, and Rashid were using incineration for treatment of their medical waste but are not currently using this technology. All hospitals in the city of Dubai used to treat their medical waste by incineration but all incinerators in the city were shut down recently, and the medical waste generated in the city is disposed of into a sanitary landfill without treatment or pretreatment except for the use of autoclave at Al Kuwait and the American hospitals. Other hospitals located in the city of Abu Dhabi (Al Mafraq and Aljazeera hospitals) are using continuous feed technology. As described in Section 2.6.5.2, continuous feed technology is characterized by size reduction of the material in an enclosed system, heating of the shredded material in a conveyor worm oil jacket at a temperature of 115 °C, disinfecting of the material via saturation vapor in thermal worm (oil jacket temperature 115 °C).

Table 4.3 Treatment of medical waste ^a

Hospital	Pathological	Infectious	Sharps	Chemical	Pharmaceutical	Pressurized containers
Al-Mafraq	CF	CF	CF	CF	- ^(b)	N/A
Al-Jazeera	CF	CF	CF	N.A	CF	N/A
Rashid	SL	SL	SL	N.A	N.A	SL
Dubai	SL	SL	SL	N.A	SL	SL
Al-Kuwait	I-1	I-1	I-1	I-1	I-1	N/A
Tawam	I-2	I-2	I-2	I-2	I-2	I-2
Al-Ain	I-2	I-2	I-2	I-2	I-2	I-2
Al-Fujerah	I-2	I-2	I-2	I-2	I-2	I-2
Saqr	I-2	I-2	I-2	I-2	I-2	I-2
Um-Alqewain	I-1	I-1	I-1	I-1	I-1	I-1
Al-Qasimi	I-1	I-1	I-1	I-1	N/A	N/A
Shiekh Khalifa	I-2	N/A	I-2	N/A	N.A	N.A
Oasis	I-2	I-2	I-2	I-2	I-2	N/A
American	SL	SL	SL	SL	SL	SL

^a CF: Continues feed technology, SL: Sanitary landfill, I-1: Incineration with one stage, I-2: Incineration with two stage

^b Pharmaceutical waste is either send to municipality or to original source

N/A=not applicable, N.A= not available

The use of incineration as a method for treating medical waste is not without its environmental problems. Serious concern has been raised about emissions of large amount of particulate matter and undesirable pollutants like dioxins and furan (Lee and Huffman, 1996). Another problem is associated with the high level of lead in the formed ash. As a result, formed ash from incinerators is treated in certain cases as a hazardous waste. Most medical waste incinerators in the UAE are very old and not working properly. The emission of black smoke is very common from these incinerators. One common practice is to add water to the content during incineration so as to cover up the black smoke with white steam. Some of the incinerators are equipped with filters, but the filters are not operational. Thus, gaseous emissions from incinerators in the country will continue to be of concern. The observations made in

this study are consistent with those reported by UN Development Program in UAE. In their report it was stated that all incinerators at visited hospitals are old and are not in good operational conditions. The study concluded that this could be the main reason for air pollution (UN Development Program, 1998).

It should be noted concerns over emissions from incinerators at medical facilities in India have lead the World Bank to promote ecologically friendly technologies for biomedical waste management in its health projects in India and not finance incinerators (Kumar, 1998).

4.5 GUIDELINES

As demonstrated in Table 4.4, there are two types of guidelines that exist at UAE hospitals for management of produced medical waste: governmental and internal guidelines. In 1999, a technical committee from the Ministry of Health established the governmental guidelines. A report entitled "Safe handling and disposal of medical waste-excluding radioactive waste" (Ministry of Health, 1999) was issued. A copy of the report is presented in Appendix C. Governmental guidelines were made available to all hospitals in the UAE through the Ministry of Health, but the administrators in some of these hospitals do not have these guidelines.

The objectives of the governmental guidelines were to define various categories of medical waste and provide guidelines for proper segregation and containment, and safe collection, storage, transportation and disposal of medical waste carried out by well trained personnel, under the supervision of suitably qualified staff, and using contemporary and eco-friendly technology. The report

classified medical waste into six categories on the basis of its risk potential and prescribed methods for its proper segregation, containment, safe collection, storage, transportation, and disposal. It is noticed that waste classifications as presented in the report are similar to the British classifications with the addition of radioactive waste. However, pathological waste was not clearly mentioned in the report. Governmental guidelines also set specifications of bags and containers used for medical waste collection. These bags are classified into four different colors and vary in other characteristics including thickness and tear resistance.

Table 4.4 Existence of guidelines for managing medical waste at UAE hospitals.

No.	Hospital Name	Government Guidelines	Internal Guidelines
1	Al-Mafraq	Yes	No
2	Al-Jazeira	Yes	Yes
3	Rashid	Yes	Yes
4	Dubai	Yes	Yes
5	Al-Kuwait	Yes	Yes
6	Tawam	Yes	No
7	Al-Ain	No	No
8	Al-Fujerah	Yes	No
9	Saqr	Yes	Yes
10	Um-Alqewain	Yes	Yes
11	Al-Qasimi	No	Yes
12	Shiekh Khalifa	Yes	No
13	Oasis	Yes	Yes
14	American	Yes	Yes

Governmental guidelines also prescribe methods of segregation, containment, collection, storage, transportation and disposal of medical waste. The report provides the code of practice for the management of medical waste to be observed by all health facilities and their designated staff and other individuals, organizations and agencies responsible for or connected with the generation, segregation, containment,

collection, storage, transportation and disposal of medical waste in UAE. The report also set recommendations regarding new modalities for medical waste disposal.

Few Emirates provide their hospitals with internal guidelines such as Dubai and Abu Dhabi. In Dubai the Central Committee for Control of Hospital Infections (CCCII) published internal guidelines entitled, "Infection control policy and guidelines" (Department of Health and Medical Services, Dubai, 1998). This manual is presented in the form of guidelines, policies, procedures, instructions and general information. The manual contains about twenty-two subjects. One subject is healthcare waste management. This subject contains six subtitles which deal with waste classification. Under this subtitle healthcare waste is classified into two distinct types: medical and domestic. Medical waste is divided by characteristics into seven groups. The manual addresses the health and safety aspects including health hazards risk to personnel and external health hazards. The manual further explores means of waste handling, storage, transportation, treatment, and disposal. The manual is based on well-documented and widely accepted recommendations according to standards established in various UK hospitals and the Center for Disease Control and Prevention (CDC) in the USA. These guidelines have a wide range of content including health and waste management.

In general, it was found that about two-thirds of the 14 surveyed hospitals indicated the existence of internal guidelines, and almost all hospitals, with the exceptions of Al-Ain and Al Qasimi, have governmental guidelines (Table 4.5). As is obvious, all the hospitals included in the survey have at least one of these guidelines with the exception of Al-Ain hospital that has none. It should be noted that at certain visited

hospitals, only some specialized departments have internal guidelines and are limited in the stated waste management practices to methods of treatment of generated waste. A distinction should be made, however, between the presence of guidelines within the healthcare institution and the implementation of these guidelines. In all surveyed hospitals, no monitoring was noticed to control the implementation of any of these guidelines. It can be concluded from the diversified guidelines used by the various hospitals that regulations are needed to verify the implementation of the applicable guidelines. In managing their medical waste, some hospitals do not have any internal written policy or procedure for handling medical waste (UN Development Program in UAE, 1998).

4.6 STAFF TRAINING --

Some professions are inherently at risk from exposure to medical waste. The most obvious are healthcare workers who come in contact with patients carrying infectious disease. Others are people who are in waste-handling occupations (Burke, 1994). The largest probability for exposure for both of these groups are needlestick injuries. As reported by Lichtveld et al. (1992), sharps cause about one-third of the work related injuries in hospitals. It is, therefore, the responsibility of the administration of a healthcare institution to monitor regularly the health and safety of their staff, patients and visitors. This means that proper handling, storage, treatment and disposal of waste should be implemented.

In an environment where medical waste regulations are properly implemented, lack of good training of workers on handling may result in a more

expensive waste disposal Boatright and Edwards (1995) discovered that many healthcare facilities were paying for the disposal of a large volume of biomedical waste that was not covered under the existing state regulations for biomedical waste management. As the author indicated, this was due to confusion among many of the surveyed institutions as to what exactly constituted biomedical waste.

Results of the survey conducted herein showed that 64% of the hospitals have specific unit that deals with medical waste management in the hospital. These units employ various numbers of staff that are responsible for transfer of waste from the patient room or various units to the storage area. At the end of the day, the waste is transferred using "specialized" vehicles to a designated incinerator or landfill. All hospitals have reported the presence of training and awareness raising programs for the staff engaged in medical waste management. Other training programs include training on handling medical waste and working with infection control programs are offered for the newly joining staff.

On-site visits revealed that hospitals are dealing with their waste through private housekeeping contractors. These contractors are recruiting poor, non-educated personals that are difficult to communicate with. Those workers lack knowledge of the risk associated with handling of medical waste. It was understood that not all the staff are included in the offered training program but it is restricted to those who are in high-risk area. Such observation is consistent with what has been reported in a study conducted by the UN Development Program (UN Development Program in UAE, 1998). In their project, the UN Development Program noticed that there are no experienced workers for hospital cleaning within the institution or any other cleaning

company. Further comments where made in the UN report concerning the lack of special supervisors or departments who monitor the handling of medical waste.

4.7 RADIOACTIVE MEDICAL WASTE IN THE UAE

Results of the survey conducted in this study showed that the use of radionuclides for diagnostic purposes for both “in vitro” and “in vivo” application is limited to few hospitals in the country (Table 4.5). Furthermore, only three isotopes are used including ^{99m}Tc, ¹³¹I, and ¹²⁵I, with the former isotope is being the only one used at the majority of the hospitals. All the isotopes used at UAE hospitals have a relatively short half-life (see Table 2.9).

Table 4.5 Radionuclides used at UAE hospitals

Hospital	Radio-nuclide	Half-life	Energy per disintegration (MeV)	Emission	Average use (mCi/month)
Tawam	^{99m} Tc	6 hr	1.2×10^{-1}	δ	180
	¹³¹ I	8 d	3.8×10^{-1}	δ,β	400
	¹²⁵ I	60 d	$<50 \times 10^{-3}$	δ,β	300
Al-Ain	^{99m} Tc	6 hr	1.2×10^{-1}	δ	400
AL-Jazeera	^{99m} Tc	6 hr	1.2×10^{-1}	δ	400
AL-Mafraq	^{99m} Tc	6 hr	1.2×10^{-1}	δ	400
Saqr	^{99m} Tc	6 hr	1.2×10^{-1}	δ	400
Al-Fujerah	^{99m} Tc	6 hr	1.2×10^{-1}	δ	400
Dubai	^{99m} Tc	6 hr	1.2×10^{-1}	δ	400

Radioactive medical waste generated in the UAE is limited to the few hospitals that are using these materials. A summary of the methods to handle radioactive medical waste in the UAE is listed in Table 4.6. Most of the hospitals perform segregation, use color-coded bags, and label these bag (Table 4.6). However, only few hospitals conduct estimates of the amount of radioactive waste generated.

Table 4.6 Handling radioactive medical waste in the UAE

No	Hospital	Segregation	Color-coded bags	Marking on bag	Estimated amount
1	Al-Mafraq	Yes	Yes	Yes	3 kg/wk
2	Al-Jazeera	-	Yes	Yes	NA
3	Dubai	Yes	-	-	NA
4	Tawam	Yes	No	Yes	NA
5	Al-Ain	Yes	Yes	Yes	1 kg/wk
6	Al-Fujerah	Yes	Yes	Yes	NA
7	Saqr	Yes	Yes	-	NA

NA= not available

During the assessment period, several on-site visits were conducted. These visits revealed that all hospitals have special storage facilities for their short half-life radioactive waste. The decay storage period varies from 2-3 weeks. This period is more than 10 times the half-life of the commonly used ^{99m}Tc . However, this period may not be sufficient to deactivate ^{131}I and ^{125}I used at Tawam hospital. At this hospital, ^{131}I is used at the Radiotherapy Department and ^{125}I at the Nuclear Medicine Department. Radioactive medical waste produced at Tawam hospital undergoes different storage periods that range from one month to less than six months.

The final destination of the “deactivated” medical waste differs among the hospitals (Table 4.7). Some hospitals incinerate their “deactivated” waste while hospitals in Dubai send the waste directly to special landfills. Al-Fujerah hospital is disposing their radioactive waste by sending it to the Civil Defense Department.

Few hospitals still use long half-life radioactive ^{137}Cs which has a half-life of about 30 years. These hospitals usually have a special storage room for long period of storage. The wall of these rooms presumably is lined with lead bricks to prevent radiation. In some hospitals these materials have been in these storage rooms since the hospital was first opened. Some hospitals (Tawam and Dubai) mentioned that long half-life radioactive materials are usually returned to vendors. Tawam started to substitute long half-life material with short half-life for ease of disposal.

Table 4.7 Destination of “deactivated” medical waste in the UAE

No	Hospital	Destination of “ deactivated” waste
1	Al-Mafraq	None
2	Al-Jazeira	Landfill
3	Dubai	Special landfill
4	Tawam	Incineration
5	Al-Ain	Incineration
6	Al-Fujerah	Handled by Civil Defense Department
7	Saqr	Incineration

In UAE there are no laws or legislation regarding management of radioactive waste. The last report on safe handling and disposal of medical waste (Ministry of Health, 1999) set guidelines for management of medical waste with the exception of radioactive waste. There is a law set by Abu-Dhabi Emirate, however, stating that medical radioactive waste should be incinerated or buried after decay storage. (Abu Dhabi Law, 1998).

CHAPTER 5

ACTIVITY AND METAL CONTENT OF ASH WASTE FROM INCINERATORS

Incineration is used by several hospitals covered in this study as the preferred method for disposal and treatment of generated medical waste. Incineration is the method used to destroy the organic constituents of hazardous waste, with the assurance that the end product is a sterile material, and can be handled and disposed of as ordinary waste. Ash samples produced from incineration of medical waste may contain, however, high levels of heavy metals, with some of these metals proven to be human carcinogen and toxic to many plants and animals. These metals may include cadmium (Cd), chromium (Cr), lead (Pb), mercury (Hg), among others.

Several studies were carried out on the heavy metals contents of particulate matters generated from the process of incineration of this type of waste. Avina and Esposito (1993) conducted a study for controlling particulate matter on test burns at a medical waste incineration facility in Baltimore. Their results showed that particulate matter contained a high concentration of heavy metals, which in turn may be found in ash constituents. Peters (1991) has reported that heavy metals most often monitored in flue gas emissions from incinerators are lead (Pb), arsenic (As), cadmium (Cd), copper (Cu), nickel (Ni), and chromium (Cr). The US Environmental Protection Agency (EPA); as quoted by Sadler (1993); has identified twelve toxic metals that pose a potential hazard to human health and the environment. Those metals are shown

in Table 5.1. Five of those metals have been identified as suspected carcinogens. They are arsenic, beryllium, cadmium, chromium, and nickel.

The disposal of incinerator ash in municipal landfills may pose an environmental threat as it may leach a portion of the metals present and consequently contaminate surrounding water bodies. It is necessary, therefore, to properly manage this waste in a manner so that once disposed of it does not cause any environmental impact. Characterization is the first step towards proper management of this waste. Thus, it is the objective of this chapter to analyze ash waste samples generated from incinerators at UAE hospitals for heavy metal content.

5.1 Toxic Metals Identified by the US EPA.

Arsenic	Barium
Beryllium	Lead
Cadmium	Mercury
Chromium	Selenium
Antimony	Thallium
Nickel	Silver

5.1 EXTRACTABLE METALS

Total extractable metal contents obtained from acid digestion of the collected ash samples are presented in Table 5.2. Also associated with the metal concentration is the standard deviation of the three split samples. As can be depicted from table 5.2, heavy metals were detected in all ash samples collected from the incinerators but at different concentration levels. Among the analyzed metals, Zn was found to have the highest levels. This is consistent with the findings of Shuwiter (1995), who analyzed ash samples for total extractable metals from four hospitals in the UAE.

Table 5.2 Extractable metals (mg/kg) from the ash waste samples.

Hospital	Cd	Cr	Cu	Ni	Pb	Zn
Shiekh Khalifa	1.1 ±0.1	535 ±5	130.66 ± 1.527	71 ± 1.732	502 ± 2.64	10100 ± 100
Al-Fujerah	6.066 ± 0.057	257.33 ± 2.081	552.66 ± 2.516	66.66 ± 1.527	394.3 ±4.041	5800 ± 600
Saqr	5.566 ± 0.057	1455 ± 13.228	156.66 ± 1.527	71.66 ± 3.05	1181 ±2.645	7600 ± 500
Al-Ain	13 ±1	1099 ± 3.605	421.66 ± 1.527	72.33 ± 2.516	202.6 ±2.516	7200 ±100
Tawam	1.533 ± 0.0577	945.66 ± 2.081	501 ± 2.645	126.33 ± 1.527	534.33 ±4.041	2900 ± 100
Um-Alqewain	2.466 ± 0.057	794.33 ± 4.041	469.33 ±1.524	55.33 ± 1.527	551.66 ±1.527	6400 ± 100
Al- Qasimi	1.133 ± 0.1154	604.3 ± 4.509	132.66 ± 2.516	27 ± 1.7320	2712 ± 10.583	4900 ± 100

High zinc in ash samples may result from the use of lubricating oil that is used quite often for various hospital machines. According to Multezou et al. (1989) lubricating oil may contain 200 to 1500 ppm of zinc. Another source for zinc is batteries which is used in the examination flashlights. Additionally, zinc may be present as impurities in fossil fuels. The incineration of metal cans or other scrap materials made of bronze in which zinc is present at 36- 42% may raise the zinc and copper levels to detectable units in ash analysis. Zinc is added to copper in metal alloys to improve the corrosion resistance of copper (Perry et al., 1984).

Zinc levels in the ash samples collected from Tawam hospital are lower than those in the ash samples from other hospitals. This may be due to the effective segregation system practiced at Tawam for waste designated for incineration. Chromium and nickel in the ash waste could have resulted from large quantities of stainless steel originally present in the waste such as sharps. Chromium is added in the manufacturing of stainless steel to improve the hardness, abrasion and corrosion resistance of iron. All types of stainless steel are made of iron with 12 to 30% chromium, and 0 to 22% nickel (Perry et al., 1984). Also, chromium in the ash waste

may result from the incineration of laboratory wastes, which contains chromic acid that is used quite often to clean glassware.

Cadmium was found to be at the lowest concentration of the extractable metals in the ash samples. Cadmium may have resulted from the discharge of batteries in the medical waste. The level of lead in the ash samples reached approximately 3 g/kg in ash waste samples collected from Al Qasimi hospital. The relatively high concentration of lead in the ash samples may be due to the disposal of teeth filling materials used by the dental clinic associated with the hospitals. Sharps, infectious waste bags, and batteries are other sources of lead in addition to the contamination of wastes with fossil fuels (gasoline). Another source of lead is printing ink used for printing newspapers. Wong and Narasimhan (1994) reported that medical waste stream of two hospitals showed that paper (mostly newspapers) comprised the second highest percentage in the waste stream.

5.2 LEACHABLE METALS

It is critical, from an environmental point-of-view, to assess if ash waste produced by hospitals is toxic. Such assessment cannot be based on total extractable metals produced after vigorous acid digestion since the waste is not exposed in the environment to conditions that are as severe to extract all metals. Thus, toxicity assessment was carried out in this study by the TCLP test that would better resemble extreme conditions the waste would be exposed to once disposed of into a landfill.

Leachable metals from the collected incinerator ash waste samples of medical waste at the surveyed UAE hospitals along with their standard deviation are shown in

Table 5.3 The results are expressed in both mg/L and mg/kg. The latter value was tabulated to allow comparison between total extractable metals (Table 5.2) and total leachable ones (table 5.3). As obvious, only a small fraction of the total metals present in the ash sample is leachable under the TCLP conditions. For example, zinc, although present at high levels in the waste, is not leachable to a large extent.

Table 5.3 TCLP test results of the ash waste samples.

Hospital	Unit	Cd	Cr	Cu	Ni	Pb	Zn
Shiekh	mg/L	<0.01	0.51±0.08	0.04±0	0.02±0	<0.05	0.26±0.10
Khahifa	mg/kg ^a	<0.2	10.2±1.6	0.8±0	0.4±0	<1	5.2±2
Al-Fujerah	mg/L	<0.01	<0.05	3.35±3.48	0.08±0.01	<0.05	11.02 ± 15.67
	mg/kg ^a	<0.2	<1	67±69.6	1.52±0.1	<1	220.4±313.4
Saqr	mg/L	<0.01	6.73±1.18	0.05±0	0.03±0.01	<0.05	1.35 ± 0.85
	mg/kg ^a	<0.2	134.6±23.7	1±0	0.6±0.1	<1	27±17
Al-Ain	mg/L	0.06±0.01	<0.05	0.11±0.01	0.19±0.05	0.14±0.03	59.13±2.82
	mg/kg ^a	1.22±0.04	<1	2.2±0.1	3.8±1	2.8±0.5	1182.6±45.6
Tawam	mg/L	<0.01	7.2±0.51	<0.03	<0.01	<0.05	0.32±0.07
	mg/kg ^a	<0.2	144±10.2	<0.6	<0.2	<1	6.4±1.4
Um-Alqewain	mg/L	<0.01	1.13±0.30	0.08±0.02	0.07±0.03	<0.05	16.73±3.82
	mg/kg ^a	<0.2	22.6±6	1.6±0.35	0.4±0.52	<1	334.6±65.6
AlQasimi	mg/L	<0.01	1.73±1.27	<0.03	0.05±0	<0.05	1.1± 0.8
	mg/kg ^a	<0.2	34.6±25.48	<0.6	1±0	<1	22±16

$$^a \frac{\text{mg}}{\text{kg ash}} = \left(\frac{\text{mg}}{\text{L}}\right)(0.4\text{L})\left(\frac{1}{20 \text{ g ash}}\right)\left(\frac{1000\text{g ash}}{\text{kg ash}}\right)$$

Further inspection of Table 5.3 showed that Cd and Pb, although were detected using the extraction test, have been detected in the leaching test only for the ash waste from Al-Ain hospital. The high leachable Cd from Al-Ain sample, as compared to other samples, could be explained on the basis that the total extractable Cd from this sample was the highest among the other samples. This reason cannot be used, however, to explain the high leachable Pb and Zn from the Al-Ain sample, as other samples have higher extractable Pb and Zn than that of Al-Ain but did not show high leachable levels of these metals. The reason for relatively high leachable Pb and Zn in Al-Ain sample is possibly due to the presence of lead and zinc in the sample,

although to a lesser extent than other samples, but it is easier to leach under the TCLP conditions. It is interesting to note that a single source like batteries present in Al-Ain incinerated waste could have contributed to the high levels of Zn, Pb and Cd in the ash samples.

Comparison of the results of the TCLP test (Table 5.3) with the US EPA established limits (Table 5.4) show that Cr levels in the waste samples from Saqr and Tawam hospitals are of concern according to the 40 Code of Federal Register. The level of all analyzed metals, with the exception of Cr at Saqr and Tawam hospitals, is even below the more stringent proposed EPA unconditional exemption regulations. Therefore, ash samples from the incinerators of the hospitals in the UAE would pass the US EPA test for toxicity given that chromium source in the waste has been reduced at both Saqr and Tawam hospitals. Similar conclusion was reached by Santansiero and Ottaviani (1995) who conducted a study on solid residues from hospital waste incineration in Italy. Their study revealed that the absolute concentration of examined metals (Cd, Cr, Cu, Ni, Pb and Zn) in slag samples was not such as to classify them as toxic and harmful.

Table 5.4 Comparison of existing TCLP leachate limits (mg/L).

Metal	40 CFR ^a part 261	CBEC ^b (unconditional Exemption)	CBEC (Conditional Exemption ^c)
Pb	5	0.15	1.5
Cd	1	0.05	0.5
Cr	5	1	10
Ni	-	1	10
Zn	-	70	700

^aCFR=Code of Federal Register

^bCBEC=conditional-Based Exemption Criteria

^cConditional exemption requires management of wastes in a landfill or a facility meeting these standards including liners.

5.3 RADIOACTIVE LEVEL

Results of analyzing collected ash samples for activity using the scintillation instrument and the Geiger counter are summarized in Table 5.5 for hospitals using radionuclides and in Table 5.6 for the ones that are not using radionuclides. Comparison between the results in the two tables shows that the activities of ash samples collected from hospitals using radionuclides are comparable to the background level. It should be indicated that natural backgrounds give count rates of the order of 0.67 c/s (IAEA, 1995). A doubling of the natural background level (i.e. > 1.3 c/s) might be considered as a positive indication of contamination (IAEA, 1995). None of the results of the scintillation instrument for the tested samples exceeded this value. Thus, it can be concluded that ash waste from incinerators is not considered contaminated with radionuclides.

Table 5.5 Activity of ash samples at UAE hospitals.

No	Hospital	δ and β detector (c/s)		Geiger counter (mR/hr)	
		Average value ^a	Standard deviation ^a	Average value ^a	Standard deviation ^a
1	Tawam	0.8	0.12	0.026	0.011
2	Al-Ain	0.37	0.065	0.04	0.005
3	Al-Fujerah	0.42	0.015	0.04	0.012
4	Saqr	0.27	0.097	0.006	0.011

^a Six trials were conducted for each sample.

Table 5.6 Background levels using ash samples from UAE hospitals not utilizing radionuclides.

No	Hospital	δ and β detector (c/s)		Geiger counter (mR/hr)	
		Average value ^a	Standard deviation ^a	Average value ^a	Standard deviation ^a
5	Um-Algewain	0.35	0.075	0.03	0.012
6	Al-Qasimi	0.21	0.13	0.01	0.015
7	Sheikh Khalifa	0.44	0.168	0.03	0.020

^a Six trials were conducted for each sample.

Analysis of the Geiger counter results would also lead to the same above conclusion. To illustrate this point, a source of 100 mCi (3700 MBq) results in an exposure rate of 22 mR/hr at a distance of 1m (Al Tamimi, 2002). The distance used in the measurement of activity of the tested ash samples was 2 cm. Applying the inverse square law, an intensity of 22 mR would result from a source of 1.48 MBq at a distance of 0.02m. The highest reading obtained using the Geiger counter for the tested samples was 0.04 mR/hr (Table 5.5). This value corresponds to a source activity of 2.7 KBq. The IAEA (1995) considers solid wastes with activity < 37 KBq as uncontaminated and may be disposed of with an appropriate volume of ordinary refuse.

Results of the gamma spectrophotometer for ash samples from Al Ain and Tawam hospitals are listed in Table 5.7. The net total photopeak count at a certain energy (specific to the radionuclide present) was obtained using instrument outputs similar to the curves shown in Fig. 5.1 and 5.2. The time of detection was fixed at one day for all the samples. The activity resulting from the presence of a certain radionuclide in the ash sample was obtained using the photopeak count, the efficiency of the instrument, the half-life of the isotope, the weight of the analyzed sample, and the time between sample measurement and collection. The equations used for this purpose are shown in the footnotes of Table 5.7.

As shown in Table 5.7, three isotopes were present at identified count levels (^{67}Ga , ^{131}I , and ^{40}K) in the ash samples collected from Tawam and Al Ain hospitals. Gallium was only present in samples collected from Tawam hospital. Although Tawam hospital did not indicate in its response to the questionnaire (Table 4.4), ^{67}Ga

is been used there for diagnoses purposes. The other two isotopes (^{125}I and $^{99\text{m}}\text{Tc}$) are not detected using gamma spectrometer. This could be due to the following reasons illustrated in Table 4.4 : (1) ^{125}I and $^{99\text{m}}\text{Tc}$ average monthly use is lower than that of ^{131}I , (2) as for $^{99\text{m}}\text{Tc}$, its half-life is short relative to the iodine isotopes, and (3) as for ^{125}I , its mean energy per disintegration is very low. The presence of ^{40}K in the ash samples is believed to be from natural sources rather than being used for medical treatment (see Table 2.8 and 2.9).

Table 5.7 indicates that the most contaminated sample is the one collected from Tawam during November (T1). It is necessary to evaluate whether this sample poses any occupational health or environmental concern given the levels of isotopes detected. To do so, one has to compare the level of activity present in this sample to a reference exempt quantity for radioactive solid disposal to a landfill or to an incinerator. Such exempt quantities have been reported by the IAEA (1991) as illustrated in Table 4.10. According to the IAEA (1991) solid waste containing 10 Bq of ^{131}I and 200 Bq of ^{125}I per gram waste can be disposed of in a landfill or can be sent to an incinerator. Table 5.7 shows that the maximum quantity of ^{131}I in the ash samples is 5.37×10^{-3} Bq/g for sample T2 and the waste does not have any ^{125}I . Exempt quantities for ^{67}Ga have not been set by the IAEA. Nevertheless, the total activity present in the most contaminated sample (T1) is 1 Bq/g, lower than any of the exempt quantities for an individual isotope in Table 5.8. Thus, ash samples collected from those selected UAE hospitals are not contaminated with radionuclides to a level that would raise an environmental concern. It should be noted, however, that the activity of ^{67}Ga in Tawam samples (T1 and T2) would have been reduced at least 85% had the waste been stored for only extra one day before being incinerated.

Table 5.7 Activity of ash samples determined by gamma spectrometer.

Location ^a	Isotope	Weight, W (g)	Half life, t _{1/2}	Energy (Kev)	Time from incineration to measurement (day)	Net total photopeak count, N	Efficiency, E	Activity at time of measurement (A Bq)	Activity corrected, A ₀	Activity of ash (Bq / kg)	Activity (Bq / day / kg)
T1	⁶⁷ Ga	369.9	78.3 h	300	5	92680	0.012	89.3	253	683.9	44457.9
	¹³¹ I		8 d	364		1061	0.012	1.02	1.57	4.25	276.6
	⁴⁰ K		0.128 y	1460		5473	7.248x10 ⁻⁴	87.3	94	254.1	16517.9
T2	⁶⁷ Ga	495.7	78.3 h	300	3	47076	0.012	45.40	85.86	173.2	5196.22
	¹³¹ I		8d	364		47076	0.012	2.054	2.66	5.37	161.2
	⁴⁰ K		0.128y	1460		5224	7.248x10 ⁻⁴	73.42	78.22	185.9	5278.7
A1	⁶⁷ Ga	264	78.3h	300	4	—	0.012	—	—	—	—
	¹³¹ I		8 d	364		—	0.012	—	—	—	—
	⁴⁰ K		0.128 y	1460		3360	7.248x10 ⁻⁴	53.6	56.9	215.5	12930
A2	⁶⁷ Ga	237.8	78.3 h	300	12	—	0.012	—	—	—	—
	¹³¹ I		8 d	364		—	0.012	—	—	—	—
	⁴⁰ K		0.128y	1460		3988	7.248x10 ⁻⁴	63.6	76	319.9	19194
A3	⁶⁷ Ga	276.6	78.3h	300		—	0.012	—	—	—	—
	¹³¹ I		8d	364		—	0.012	—	—	—	—
	⁴⁰ K		0.128 y	1460		2727	7.248x10 ⁻⁴	43.5	55.2	199.5	11970
T3	⁶⁷ Ga	1363.7	78.3 h	300	4 ^b	—	0.012	—	—	—	—
	¹³¹ I		8 d	364		—	0.012	—	—	—	—
	⁴⁰ K		0.128 y	1460		13408	7.248x10 ⁻⁴	—	—	—	—
A4	⁶⁷ Ga	2496.5	78.3 h	300	4 ^b	—	0.012	12.93	19.8	7.93	475.8
	¹³¹ I		8 d	364		—	0.012	—	—	—	—
	⁴⁰ K		0.128 y	1460		—	7.248x10 ⁻⁴	427.9	441.1	176.7	10614

^a T for Tawam Hospital and A for Al Ain Hospital.

^b Average time was taken for the six days of sample collection.

Column 2: Weight of ash sample used in the measurement.

Column 4: Energy level specific to different isotopes.

Column 6: Determined from the gamma spectrograph (see Fig. 5.1 and 5.2)

Column 7: Predetermined for the spectrometer using calibration standards.

Column 8: $A = \frac{N}{86,400E}$, Column 9: A₀ determined using $A = A_0 e^{-\lambda t}$, Column 10 = A₀/W

Table 5.8 Reference exempt quantities for solid disposals to a landfill or to an incinerator (IAEA, 1991).

Radionuclide	Total activity in a single package (Bq)	Average activity concentration in the waste (Bq/g)
^{67}Ga	NA	NA
$^{99\text{m}}\text{Tc}$	3×10^8	1×10^2
^{125}I	2×10^5	2×10^2
^{131}I	2×10^5	1×10^1
^{40}K	NA	NA

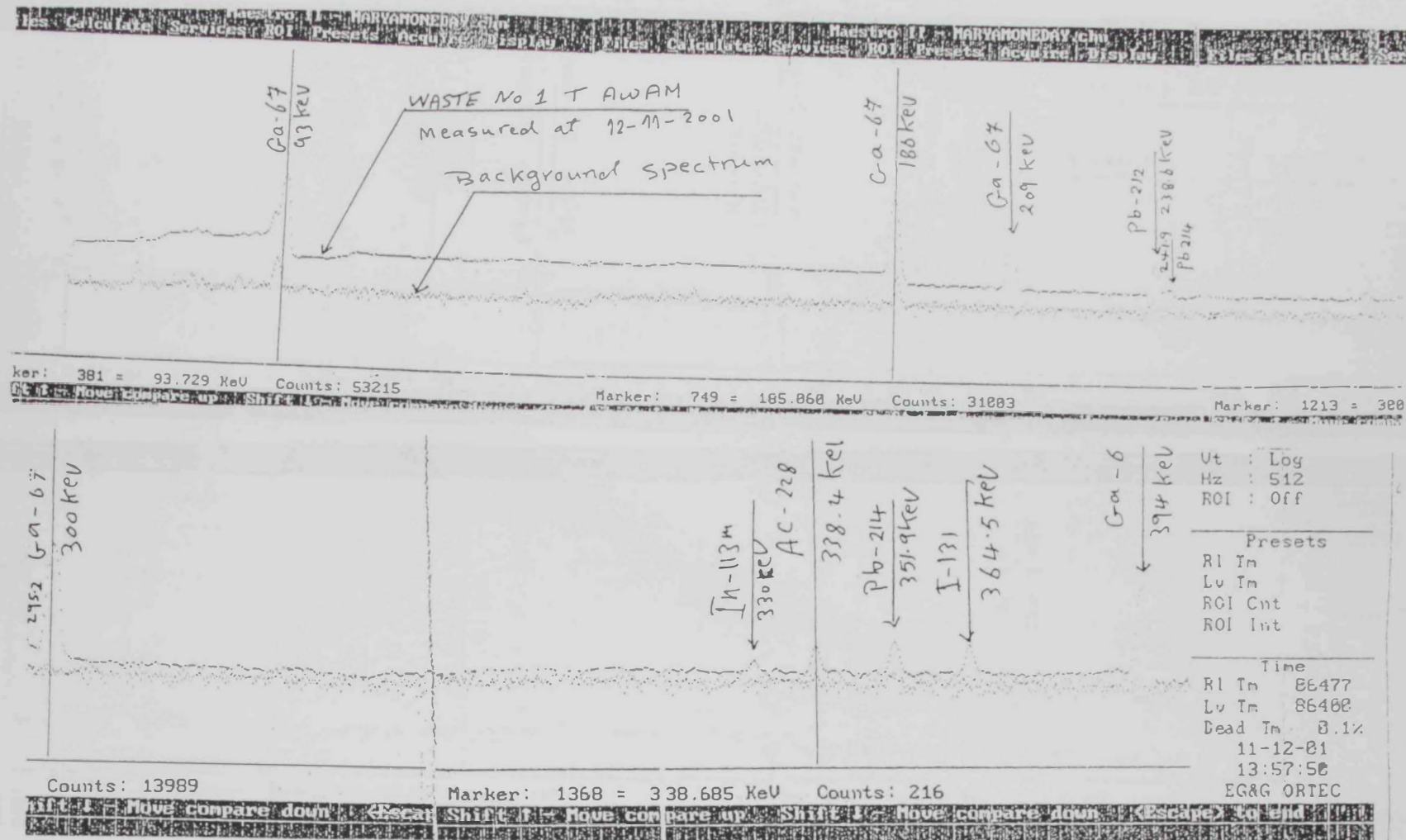


Fig. 5.1 Level of radiation and the type of isotopes for ash samples collected at Tawam hospital as determined by gamma spectrometry.

CHAPTER 6

CONCLUSIONS AND RECOMMENDATIONS

6.1 CONCLUSIONS

Medical waste is a growing, pressing problem, which will become more complex in the future. The expense of proper disposal as well as implementation of regulatory programs should escalate, adding millions to health provision costs. The main objective of this study was to assess medical waste management in the UAE, including waste generation, handling, treatment and disposal. The study focused on medical waste generated mainly by governmental hospitals and did not include that portion of waste generated by private and public clinics. From this study it can be concluded that:

1. The average rate of medical waste generated at UAE hospitals is 1.95 kg/bed/ day, with high variations in this rate (i.e. 0.2 to 4.5 kg/bed/day) among the surveyed hospitals. The higher rate in medical waste generation is possibly due to expanded specialization and allocated hospital budget. While the total quantity of medical waste generated at UAE hospitals is known, most of the hospitals do not estimate the quantity of each type of medical waste generated.
2. The average rate of medical waste in the UAE is lower than values reported in European countries and the US. This is possibly due to the limited types of operations in the UAE, the lesser use of disposable materials, and the existence of other medical support facilities besides hospitals in the country.

3. Based on responses to a distributed questionnaire, all surveyed hospitals apply segregation procedures for pathological, sharps, and infectious waste but not all hospitals practice segregation of chemical, pharmaceutical and pressurized containers.
4. Most of the UAE hospitals are using two-color coded bags: black for domestic-type waste and yellow for medical waste, with no standardized thickness of yellow bags among the surveyed hospitals. Furthermore, not all hospitals are practicing marking on the disposed bags and containers.
5. Most of the hospitals do not have pretreatment capabilities for generated medical waste due possibly to budget constraints.
6. There is a separate on-site storage room for medical waste at most UAE hospitals. On-site transportation of medical waste for incineration treatment is conducted using special vehicles at certain hospitals or trolleys at others. Off-site transportation for treatment or disposal is conducted using special vehicles.
7. Not all hospitals employ a waste tracking system during transportation from the point of generation to the point of disposal. There was not good control on the proper disposal of yellow bags, with bags at certain locations being disposed into dumpsters designated for domestic waste.
8. Surveyed hospitals are using contractors for handling generated waste. All hospitals have reported the presence of training program for the cleaning staff of the contractor.
9. Incineration is used by most hospitals in the UAE for the destruction of infectious pathogens. Most incinerators are old and poorly maintained with no proper equipment to control air pollution.

10. Incineration of medical waste is not practiced at hospitals in the city of Abu Dhabi-where continuous feed technology is used nor at hospitals in the city of Dubai where sanitary landfills are employed.
11. Ash samples collected from incinerators of hospitals in the UAE showed that toxic metals, with the exception of Cr at certain locations, do not exceed the TCLP regulatory limits.
12. The use of radionuclides in UAE hospitals is limited to three treatment isotopes and one for diagnostic purposes, with all radionuclides having relatively short half-lives. All surveyed hospitals have special storage facilities for their radioactive waste with a decay storage period that varies from two to three weeks and could reach six months in certain cases, depending on the isotope present in the waste.
13. Ash samples collected from incinerators of hospitals using radionuclides in the UAE showed the level of activity is below the limit established by the International Atomic Energy Agency.
14. Federal guidelines for management of medical waste exist but are not strictly implemented by the hospitals. Guidelines set by the Central Committee for Control of Hospitals Infections in Dubai are strictly applied by hospitals in the Emirate.

6.2 RECOMMENDATIONS

1. A competent authority should coordinate with other sectors in the country to establish a federal policy for medical waste management. Such policy should be

strictly applied by hospitals. Means to monitor the implementation of the established policy should also be allocated.

2. The Ministry of Health should continuously update the guidelines for the management of medical waste. The published report on "Safe handling and disposal of medical waste-1999" should provide a very good base whenever new guidelines are to be established.
3. Regulations concerning the collection, handling, and disposal of radioactive medical waste should be established and means for proper monitoring of waste activity should be implemented.
4. Municipalities should provide the necessary infrastructure for collection, transportation, and disposal of medical waste and enforce the provisions of the law in the management of medical waste.
5. Hospitals should coordinate activities among different departments such that better management can be achieved and accidents can be better controlled. It is also recommended that hospitals document all cases of infection or poisoning caused due to exposure or handling of medical waste.
6. Generation of medical waste could be reduced by using non-disposal items. Options for using recyclable material should be explored and be adopted whenever feasible.
7. Hospital managers should train their staff to become aware of hazards from infected or toxic waste-especially from infected sharps.
8. Bags containing chemical or infectious waste should follow established standards in terms of tear resistance and of being liquid proof.
9. Immunization against Hepatitis B should be given to all hospital workers at risk especially nurses, auxiliaries and porters.

10. Incineration of medical waste, whenever used, should be implemented using state-of-art incinerators equipped with pollution control devices, and operated by well-trained individuals. Monitoring of air pollutants emitted from incinerators is highly recommended.

11. Ash samples from incinerators should be monitored for toxicity. In this regard, chromium should be reduced from the source by using less chromium or equipment that is free of chromium if possible.

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QUESTIONNAIRE ON HEALTH CARE WASTE MANAGEMENT (HCWM)

1. General

a) Name of the health care establishment (hospital, clinic, health center, etc):
.....

Private ☐

Public ☐

b/1) For hospitals: Number of beds:.....

Annual percentage bed occupancy:.....

b/2) For other health care establishments: Number of admissions per year:.....

c) Estimated total HCW (kg/day or kg/year):.....

2. Legislation on HCWM

a) Governmental guidelines on HCWM exist Yes/No

☐

b) Internal guidelines of the establishment on HCWM exist Yes/No

☐

3. Handling of Clinical Waste (CW)

Components of clinical waste	Segregation is practiced at source (Yes/No)	Segregation is practiced at source by		Estimated amounts of components of clinical waste
		Color Coding of bags (Yes/No)	Marking on bags/containers (Yes/No)	
Pathological				
Infectious				
Sharps				
Chemical				
Radioactive				
Pharmaceutical				
Pressurized containers				

4. Pretreatment Applied for Clinical Waste

Components of clinical waste	No Pre-treatment applied (NAP)* (Yes/No)	Micro-wave (Yes/No)	Autoclave (Yes/No)	Gas/ Vapour (Yes/No)	Irradiation (Yes/No)	Chemical disinfection for liquidCW (Yes/No)
Pathological waste						
Infections waste						
Sharps						
Chemical waste						
Radioactive waste						
Pharmaceutical waste						
Pressurized containers						

*If NPA is used in the first column for a component of CW, then no need to fill other columns for that component.

5. Storage and Transportation of Clinical Waste

	Yes	No
a) Is there separate storage for clinical waste on site?		
b) Is storage facility disinfected periodically?		
c) Is there refrigerated storage for pathological waste on site?		
d) Are there dedicated carts/vehicles for transporting clinical waste within the health care establishment (HCE)?		

e) Please describe how the different types of clinical waste are transported for disposal.

.....

.....

.....

.....

.....

6. Treatment of Clinical Waste

Type of clinical waste	Incineration (Yes/No)	Others (please specify)
Pathological waste		
Infectious waste		
Sharps		
Chemical waste		
Radioactive waste		
Pharmaceutical waste		
Pressurized containers		

7. Disposal of Clinical Waste.

Type of clinical waste	Open dump (Yes/No)	Sanitary landfill (Yes/No)	Special landfill (toxic waste etc)
Pathological waste			
Infectious waste			
Sharps			
Chemical waste			
Radioactive waste			
Pharmaceutical waste			
Pressurized containers			

8. Characteristics of Incinerator, if Available

a) Location of incinerator

	Yes	No
Incinerator is within the health care establishment		

b) Type of incinerator

	One stage (Yes/No)	Two stage (Yes/No)
Type of incinerator		

c) Temperature of burning in the stages of incinerator

	First stage	Second stage
Specify the temperature of burning in each stage		

9. Air Pollution Control Equipment in Incinerators

	Particulate (Yes/No)	Other pollutants ^a (Yes/No)
Equipment to remove the following pollutants from gas is installed in the incinerator		

^a If yes, please mention what the other pollutants are:

10. Staff and responsibilities

a) Is there a specific unit that deals with the clinical waste management in your HCE?

Yes /No

b) How many staff is employed in this unit?

c) What are the responsibilities of these staff?

11. Training and Awareness

a) Is there any training or awareness raising program for the staff engaged in clinical waste management?

Yes /No

b) What type of staff training program is offered?

APPENDIX B

Table B.1. Segregation of different types of medical waste

No.	Hospital	Pathological	Infectious	Sharps	Chemical	Pharmaceutical	Pressurized containers
1	Al-Mafraq	Y	Y	Y	Y	N	N/A
2	Al-Jazeera	Y	Y	Y	N.A	Y	N
3	Tawam	Y	Y	Y	Y	Y	Y
4	Al-Ain	Y	Y	Y	N	N	N
5	Rashid	Y	Y	Y	N.A	N.A	Y
6	Dubai	Y	Y	Y	N.A	Y	Y
7	Al-Kuwait	Y	Y	Y	Y	Y	Y
8	Al-Fujerah	Y	Y	Y	Y	Y	N
9	Saqr	Y	Y	Y	Y	Y	Y
10	Um-Alqewain	Y	Y	Y	Y	N	N
11	Al-Qasimi	Y	Y	Y	N.A	N.A	N.A
12	Shiekh Khalifa	Y	Y	Y	N.A	Y	N
13	Oasis	Y	Y	Y	Y	Y	N/A
14	American	Y	Y	Y	Y	Y	N.A

N.A= not available, N/A=not applicable

Table B.2. Use of color-coded bags

No.	Hospital	Pathological	Infectious	Sharps	Chemical	Pharmaceutical	Pressurized containers
1	Al-Mafraq	Y	Y	Y	Y	N	N/A
2	Al-Jazeera	Y	Y	Y	N.A	Y	N
3	Tawam	Y	Y	Y	Y	Y	Y
4	Al-Ain	Y	Y	Y	N	N	N
5	Rashid	Y	Y	Y	N.A	N.A	Y
6	Dubai	Y	Y	Y	N.A	Y	Y
7	Al-Kuwait	Y	Y	Y	Y	Y	Y
8	Al-Fujerah	Y	Y	Y	N	Y	N
9	Saqr	Y	Y	Y	Y	Y	Y
10	Um-Alqewain	Y	Y	Y	N	N	N.A
11	Al-Qasimi	Y	Y	Y	N.A	N.A	N.A
12	Shiekh Khalifa	Y	Y	Y	N	N	N
13	Oasis	Y	Y	Y	Y	N.A	N/A
14	American	Y	Y	Y	Y	Y	N.A

N.A= not available, N/A= not applicable

Table B.3. Labeling of bags and containers

No.	Hospital	Pathological	Infectious	Sharps	Chemical	Pharmaceutical	Pressurized containers
1	Al-Mafraq	N	N	Y	N	Y	N/A
2	Al-Jazeera	Y	Y	Y	N.A	Y	N
3	Tawam	Y	Y	Y	Y	Y	Y
4	Al-Ain	Y	Y	Y	N	N	N
5	Rashid	Y	Y	Y	N.A	N.A	N.A
6	Dubai	Y	Y	Y	Y	Y	Y
7	Al-Kuwait	N.A	N.A	N.A	N.A	N.A	N.A
8	Al-Fujerah	N	N	Y	N	Y	N
9	Saqr	N.A	N.A	N.A	N.A	N.A	N.A
10	Um-Alqewain	N	N	N	N	N	N
11	Al-Qasimi	N	N	N	N.A	N.A	N.A
12	Shiekh Khalifa	Y	N	Y	N	Y	N
13	Oasis	Y	Y	Y	Y	Y	N/A
14	American	Y	Y	Y	Y	Y	N.A

N.A= not available , N/A= not applicable.

APPENDIX C

Safe Handling and Disposal of Medical Waste

(Excluding Radioactive Waste)

July 27, 1979



Safe Handling and Disposal of Medical Waste (Excluding Radioactive Waste)

Report of the Technical Committee Ministry of Health

July 27, 1999



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Safe Handling and Disposal of Medical Waste
(Excluding Radioactive Waste)

REPORT OF THE TECHNICAL COMMITTEE
MINISTRY OF HEALTH

May 18, 1999

A. PREAMBLE

I. OBJECTIVES AND SCOPE:

- a. The objectives of this Report on 'Safe Handling and Disposal of Medical Waste' is to:
 - i. Define various categories of medical waste on the basis of risk potential; and
 - ii. Provide guidelines for proper segregation and containment, and safe collection, storage, transportation and final disposal of medical waste carried out:
 - by well trained personnel,
 - under the supervision of suitably qualified staff,
 - using contemporary and eco-friendly technology.
- b. The Report essentially contains:
 - i. Classification of medical waste;
 - ii. Specifications of bags and containers; and
 - iii. Prescribed methods of segregation, containment, collection, storage, transportation and disposal of medical waste.
- c. This Report also provides:
 - i. Policies, procedures and guidelines for the management of medical waste to be observed by all health facilities and their designated staff and other individuals, organizations and agencies responsible for or connected with the generation, segregation, containment, collection, storage, transportation and disposal of medical waste in the United Arab Emirates; and
 - ii. Recommendations regarding new modalities for medical waste disposal.



2. ACKNOWLEDGEMENTS:

- a. The Committee especially recognizes the significant contributions of the following experts, contributors and special invitees to its deliberations:
 - i Dr. Saad Al Numairy, Environmental Advisor, Federal Environment Agency, United Arab Emirates.
 - ii Mr. Michael Fahey, Pharmacy Advisor, Ministry of Health, Abu Dhabi.
 - iii Dr. Amin Mohamed Yousuf, Director, Food & Environment Control Center, Abu Dhabi.
 - iv Ms. Colette Boileau, Environmental Awareness Officer, Food and Environment Control Center, Abu Dhabi.
 - v Dr. Mokhtar Larbi, Advisor Occupational Health, Preventive Medicine Department, Ministry of Health, Al Ain.
 - vi Ms. Massoomah Al Ansari, Head of General Services, Al-Jazeera & Central Hospitals, Abu Dhabi.
 - vii Mr. Mohammed Faris, Assistant Chief, Health Section, Abu Dhabi Municipality & Town Planning.
 - viii Dr. Tariq Younes, Chief Health Inspector, Abu Dhabi Municipality & Town Planning.
 - ix Mr. Mohammed Mousa Mustafa, Health Section, Abu Dhabi Municipality & Town Planning.
- b. The Convenors and the Members of the following Task Forces, constituted by the Technical Committee for formulating recommendations on specific issues, made very significant contributions to this report:
 - i **Methods of Storage, Transportation and Disposal of Medical Waste (other than Radioactive Waste)** - Convenor: Mr. Michael Isaacs, Chief of Preventive Medicine, Tawam Hospital, Al Ain.
 - ii **Code of Practice for Medical Waste Management (excluding Radioactive Waste)** - Convenor: Ms. Alice Calder, Director of Nursing, Al-Jazeera Hospital, Abu Dhabi.
 - iii **Policies, Procedures and Guidelines for the Management of Radioactive Waste** - Convenor: Dr. Roger Cheesman, Advisor, Ministry of Health, Abu Dhabi.
 - iv **Pretreatment and Disposal of Bio-Hazardous Laboratory Waste** - Convenor: Dr. William Dibb, Head of Microbiology, Al Jazeera Hospital, Abu Dhabi.



- v Protection of Staff involved in handling Medical Waste -
Convenor: Dr. Mokhtar Larbi, Advisor, Preventive Medicine
Department, Ministry of Health, Abu Dhabi.

3. REFERENCES:

- a. Law No. 4 of 1998 governing Medical Waste: Crown Prince Court, Emirate of Abu Dhabi, 1998.
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- d. Controlled Waste Regulations (SI588), United Kingdom, 1992.
- e. Medical Waste Management in the United Arab Emirates: Short Summary by Dr. Sa'ad Al Numairi, Federal Environment Agency, United Arab Emirates, 1994.
- f. Best Practical Means for the Segregation, Handling, and Transportation of Medical Waste: Environmental Protection and Safety Section, Dubai Municipality Health Department, 1992.
- g. Recommendations by Dr. Amin M. Yousuf, Director, Food and Environment Control Center, Abu Dhabi, 1998.
- h. Intent of the Abu Dhabi Law (4) of 1998: Memorandum by Dr. Amin M. Yousuf, Director, Food and Environment Control Center, Abu Dhabi, 1998.
- i. Safe Disposal of Pharmaceutical Waste: MOH Hospital Pharmacy Standards, 1998.
- j. End of Mission Report on Radioactive Waste Disposal: The International Atomic Energy Agency (WAMAP) Mission to the United Arab Emirates, 1994.
- k. Waste Collection: Local Authorities-Health & Environment Briefing Pamphlet Series No. 8, WHO Regional Office for Europe, 1995.
- l. Waste Management in Abu Dhabi: Reports by Tom Hall, Consultant, Environmental Protection Section, Food & Environment Control Center, Abu Dhabi, 1998:
 - i Disposal of Health Care Waste, Code of Practice.
 - ii Radioactive Waste Management for Hospitals.



- iii The Management of Health Care Waste, Outline Action Plan, Policy, and Strategy.
- iv The Management of Health Care Waste, Waste Management Audits.

B. DEFINITION & CLASSIFICATION OF MEDICAL WASTE

1. DEFINITION OF MEDICAL WASTE:

- a. Any potentially infectious, toxic or radioactive material arising from medical, nursing, dental, veterinary, pharmaceutical or similar practice, during investigation, treatment, care, teaching or research, being waste, which may be hazardous to any person, the community or the environment during its generation, segregation, containment, collection, storage, transportation or disposal, is defined as 'medical waste'.

2. CLASSIFICATION OF MEDICAL WASTE:

(Adopted from Abu Dhabi Law No. 4 of 1998 Governing Medical Waste)

Important: *Medical waste is classified under the following six categories on the basis of its risk potential and the prescribed methods for its proper segregation and containment, and its safe collection, storage, transportation and disposal.*

a. Group 'A' Medical Waste:

Dressings, bandages, soiled covers and other infectious waste such as foul and infected linen other than garments and bed linen; all human tissues, whether infected or otherwise; animal carcasses and tissues and related linen, swabs and dressings, whether infected or otherwise.

b. Group 'B' Medical Waste:

Used and discarded syringes and needles, cartridges, ampoules and containers of pharmaceutical products, broken glass, stitch cutters, blades, razors and all other contaminated disposable instruments, surgical tool and sharp objects.

c. Group 'C' Medical Waste:

Laboratory waste including blood, other tissues, microbiological cultures, live vaccines and other potentially infected waste from clinical and research laboratories and post-mortem rooms, other than the medical waste listed under Groups 'A' and 'B' above.



d. **Group 'D' Medical Waste:**

Pharmaceutical products and chemicals that qualify as medical waste including unused, damaged or expired drugs rendered unsuitable for consumption; cytotoxic, mutagenic and carcinogenic substances; narcotics and controlled drugs; and laboratory chemicals and solvents other than medical waste listed under Groups 'A', 'B' and 'C' above.

e. **Group 'E' Medical Waste:**

Disposable sheets and covers of bedside receptacles of human secretions or excretions, covers of urine containers and items used to dispose of urine, feces and other bodily secretions or excretions, including but not limited to disposable bed pans or bed pan liners, stoma bags and urine containers.

f. **Group 'F' Medical Waste:**

Radioactive waste generated during diagnosis and therapy.

C. SPECIFICATIONS OF WASTE BAGS & CONTAINERS

1. SPECIFICATIONS FOR WASTE BAGS:

a. **General Specifications for all Waste Bags:**

- i Bag size should not exceed one meter in length,
- ii Each bag should have a horizontal marking line, with a warning sign 'Do not fill above this line', to indicate when 65 % full and ready for closure,
- iii Each bag should have an easily visible label printed at a prominent and easily visible location providing the following information:
 - Name of the Institution
 - Location of Generation & Containment of Waste
 - Date and Time of Sealing the Bag
 - Date and Time of Collection of Bag for Disposal
 - Name and Location of Destination for Disposal



b. Detailed Specifications for Waste Bags:

i Red, Heavy Duty Polyethylene Bags:

Color:	Red
Performance:	Heavy Duty, Tear Resistant
Min. Thickness:	400 Gauge (100 microns)
Material:	Virgin Polyethylene
Opacity	40 %
Weld Strength	Continuous leak-proof welding
Warning Sign	Highly Infectious Material Group 'A' Medical Waste For Incineration Only

ii Yellow, Heavy Duty Polyethylene Bags:

Color:	Yellow
Performance:	Heavy Duty, Tear Resistant
Min. Thickness:	400 Gauge (100 microns)
Material:	Virgin Polyethylene
Opacity	40 %
Weld Strength	Continuous leak-proof welding
Warning Sign	Toxic Material Group 'D' Medical Waste For Incineration Only

iii Blue, Heavy Duty, Sterilizable Bags:

Color:	Blue
Performance:	Heavy Duty, Tear Resistant, Sterilizable
Min. Thickness:	160 Gauge (40 microns)
Material:	Autoclave Grade Cast Propylene or material suitable to withstand temperatures of 160 ⁰ C.
Heat Indicator	Bags must be supplied with a heat process indicator for exposure to temperatures above 120 ⁰ C.
Opacity	Transparent
Weld Strength	Continuous leak-proof welding
Warning Sign	Highly Infectious Material Group 'C' Medical Waste Sterilize Before Disposal



iv Yellow, Medium Duty, Polyethylene Bags:

Color:	Yellow
Performance:	Medium Duty, Tear Resistant, Sterilizable
Min. Thickness:	200 Gauge (50 microns)
Material:	Virgin Polyethylene
Opacity:	40 %
Weld Strength:	Continuous leak-proof welding
Warning Sign:	Hazardous Material Group 'E' Medical Waste For Incineration Only

2. SPECIFICATIONS FOR SHARPS CONTAINERS:

a. General Specifications:

- i Yellow, rigid, lightweight, single-use sharps containers.
- ii Made of hard, puncture and chemical resistant, non-polluting, translucent plastic material that can be safely incinerated.
- iii Provided with leak proof closure device that should not be openable after closure, and should prevent spillage or leakage even when the container is toppled or dropped during handling and transportation,
- iv Provided with a handle that is not a part of the closure device and does not obstruct the opening of the container or interfere with its normal use,
- v Designed to provide maximum safety against its contents spilling or falling out when handled or moved while in use,
- vi Opening of the container to be large enough to permit easy disposal of sharps into the container using one hand, without contaminating the exterior of the container,
- vii Opening to be small enough to inhibit manual removal of contents during normal use,
- viii Horizontal marking line to indicate when 75 % full and ready for closure, with a warning sign 'Do not fill above this line'.
- ix Warning sign to indicate the following:

**Contaminated Sharp Objects
Group 'B' Medical Waste
For Incineration Only**



D. POLICIES, PROCEDURES & GUIDELINES FOR MANAGEMENT OF MEDICAL WASTE

(Excluding Radioactive Waste)

I. INTRODUCTION:

- a. Disposal of medical waste outside the designated containers and in violation of the prescribed guidelines is prohibited and is punishable under the Law.
- b. It is the responsibility of each health facility that all medical waste is managed in accordance with the Law and the prescribed guidelines for:
 - i its proper segregation and containment at the point of generation, and
 - ii its collection and storage within the health facility.
- c. It is also the responsibility of each health facility to make necessary arrangements, in accordance with the municipal regulations, for:
 - i safe transportation of the medical waste to the point of destination, and
 - ii its final disposal.
- d. The objectives of this 'code of practice' is to provide necessary policies, procedures and guidelines to enable the health facilities and their staff, responsible for or connected with the generation, containment, collection, storage, transportation and final disposal of medical waste, to abide by the statutory requirements under the Law.
- e. It will also give necessary guidelines to the health facilities to:
 - i formulate their operating policies and procedure,
 - ii clearly assign functions and responsibilities to the staff,
 - iii train the staff suitably and adequately,
 - iv institute regular monitoring and audit procedures,
 - v take prompt remedial measures in the event of a default, and
 - vi ensure full compliance of the Law.
- f. It will also give the option to the health facilities to assign or sub-contract some of the functions of medical waste management to authorized agencies, licensed by the municipalities, to meet their obligations under the Law.
- g. The medical waste is classified under different categories on the basis of its risk potential and the prescribed methods of its disposal.



- h. The issue concerned with the management of radioactive waste is under consideration of alternative technical committee constituted by the Ministry of Health.
- i. The following guidelines, therefore, focus on the management of infectious and hazardous wastes, including clinical waste, sharp objects, laboratory waste, and pharmaceutical products and chemicals, but excluding the radioactive waste.
- j. It is believed that the success in the implementation of the following policies, procedures and guidelines will largely depend upon the knowledge and skills of the staff responsible for the management of medical waste.
- k. The need to disseminate necessary information to all concerned and to train the supervisory and line staff in the management of medical waste is strongly emphasized.
- l. The ready availability of all material resource, including the prescribed waste bags and containers, at all times is also emphasized.

2. SEGREGATION & CONTAINMENT OF MEDICAL WASTE:

a. Group 'A' Medical Waste:

Including: Dressings, bandages, soiled covers and other infectious waste such as foul and infected linen other than garments and bed linen; all human tissues, whether infected or otherwise; animal carcasses and tissues and related linen, swabs and dressings, whether infected or otherwise.

- i Group 'A' Medical Waste should be collected in suitable red, heavy-duty polyethylene bags, as specified in this 'code of practice'.
- ii The bags should be mounted on sack holders and placed in secured area accessible to the staff on duty but not easily accessible to the general public, at each location where group 'A' medical waste is generated.
- iii The bags should be sealed, labeled and replaced at least once daily or when 65 % full, whichever is earlier.
- iv The bags should be 'carefully sealed' with a purpose made plastic tie or closure or heat sealed if such a facility is available.
- v The sealed bags should be properly labeled indicating the name of the health facility, the location of generation of medical waste, the date and time of sealing the bag and the destination for final disposal.



- vii The sealed and labeled bags should then be left at a safe pre-determined location for collection and transportation for disposal.
- viii Only a 'permanent marker pen' or pre-printed 'Hi Tech' non-removable self-adhesive labels should be used for labeling the bags.
- ix Always remember that Group 'C' Medical Waste, over-bagged after autoclaving in the Yellow, Heavy-Duty Polyethylene bag is still considered potentially hazardous and is 'for Incineration only'.

Important: Health facilities, which generate small volumes of group 'C' medical waste and do not have facilities for autoclaving, must make special arrangements for its safe handling and disposal by incineration as group 'A' medical waste, under direct supervision of qualified Staff.

Important: Health facilities, which generate large volumes of group 'C' medical waste and do not consider autoclaving as feasible or preferred option, must deploy alternative modalities of sterilization of bio-hazardous medical waste, such as chemical sterilization with per-acetic acid or chlorine dioxide.

d. Group 'D' Medical Waste:

Including: Pharmaceutical products and chemicals that qualify as medical waste such as unused, partially used or expired drugs and pharmaceuticals rendered unsuitable for consumption; cytotoxic, mutagenic and carcinogenic substances; narcotics and controlled drugs; and laboratory chemicals and organic solvents; other than medical waste listed under Groups 'A', 'B' and 'C' above

(Important) The disposal of pharmaceutical products and chemical substances, which qualify as Group 'D' Medical Waste, must be carried out under strict supervision of a suitably qualified and authorized person as prescribed.

d (a) Pharmaceutical Products:

- i Disposal of pharmaceutical products, which qualify as Group 'D' Medical Waste, must be carried out under strict supervision of a suitably qualified and authorized Pharmacist.
- ii All pharmaceutical products that qualify as Group 'D' Medical Waste must be returned in the original dispensed container to a pre-designated area in the Pharmacy from which these were issued.



generation of medical waste, the date and time of sealing the container and the destination for final disposal.

- ix The sealed and labeled sharps container should be left at a safe pre-determined location for collection and transportation for disposal.
- x Only a 'permanent marker pen' or pre-printed 'Hi Tech' non-removable self-adhesive labels should be used for labeling the sharps containers.
- xi Always remember that Group 'B' Medical Waste, collected in the Yellow, Rigid Sharps Containers is highly infectious and is 'for Incineration only'.

c. Group 'C' Medical Waste:

Including: Laboratory waste including blood, other tissues, microbiological cultures, live vaccines and other potentially infected waste from clinical and research laboratories and post-mortem rooms, other than the medical waste listed under Groups 'A' and 'B' above.

Important: *Group 'C' Medical Waste should be sterilized and rendered safe before collection and transportation for final disposal.*

- i Group 'C' Medical Waste should be collected in suitable blue, heavy-duty, sterilizable polyethylene bags, as specified in this 'code of practice'.
- ii The bags should be mounted on sack holders and placed in secured area accessible to the staff on duty but not easily accessible to the general public.
- iii The bags should be loosely sealed, labeled and replaced at least once prior to the end of each duty shift, and definitely at the end of each working day prior to the closure of the laboratory or post-mortem room, or when 65 % full, whichever is earlier.
- iv The bags destined for autoclaving should be handled very carefully to avoid any leakage or spillage during handling and transportation.
- v The sterilized bags should be over-bagged with yellow, heavy-duty, polyethylene bags, carefully sealed with a purpose made plastic tie or closure or heat sealed if such a facility is available.
- vi The sealed bags should be properly labeled indicating the name of the health facility, the location of generation of medical waste, the date and time of sealing the bag and the destination for final disposal.



- vii The sealed and labeled bags should then be left at a safe pre-determined location for collection and transportation for disposal.
- viii Only a 'permanent marker pen' or pre-printed 'Hi Tech' non-removable self-adhesive labels should be used for labeling the bags.
- ix Always remember that Group 'C' Medical Waste, over-bagged after autoclaving in the Yellow, Heavy-Duty Polyethylene bag is still considered potentially hazardous and is 'for Incineration only'.

Important: Health facilities, which generate small volumes of group 'C' medical waste and do not have facilities for autoclaving, must make special arrangements for its safe handling and disposal by incineration as group 'A' medical waste, under direct supervision of qualified Staff.

Important: Health facilities, which generate large volumes of group 'C' medical waste and do not consider autoclaving as feasible or preferred option, must deploy alternative modalities of sterilization of bio-hazardous medical waste, such as chemical sterilization with per-acetic acid or chlorine dioxide.

d. Group 'D' Medical Waste:

Including: Pharmaceutical products and chemicals that qualify as medical waste such as unused, partially used or expired drugs and pharmaceuticals rendered unsuitable for consumption; cytotoxic, mutagenic and carcinogenic substances; narcotics and controlled drugs; and laboratory chemicals and organic solvents; other than medical waste listed under Groups 'A', 'B' and 'C' above.

Important: The disposal of pharmaceutical products and chemical substances, which qualify as Group 'D' Medical Waste, must be carried out under strict supervision of a suitably qualified and authorized person as prescribed.

d (a) Pharmaceutical Products:

- i Disposal of pharmaceutical products, which qualify as Group 'D' Medical Waste, must be carried out under strict supervision of a suitably qualified and authorized Pharmacist.
- ii All pharmaceutical products that qualify as Group 'D' Medical Waste must be returned in the original dispensed container to a pre-designated area in the Pharmacy from which these were issued.



- iii **Non-hazardous pharmaceutical products:** Non-hazardous pharmaceutical products including unused, partially used or expired drugs should be collected in yellow, heavy duty polyethylene bags as specified in this 'code of practice'.
- iv The bags should be mounted on sack holders and placed in a secured pre-designated area in the Pharmacy accessible only to the authorized pharmacy staff.
- v The bags should be closed when 65 % full or before and 'carefully sealed' with a purpose made plastic tie or closure or heat sealed, if such a facility is available.
- vi The sealed bags should be properly labeled indicating the name of the health facility, location, name and designation of the authorized person under whose supervision the bag was sealed, the date and time of sealing the bag and the final destination for disposal.
- vii The sealed and labeled bags should be placed in the secured pre-designated area in the Pharmacy for collection, transportation and disposal.
- viii Only a 'permanent marker pen' or pre-printed 'Hi Tech' non-removable self-adhesive labels should be used for labeling the bags.
- ix All activities from segregation and containment of non-hazardous pharmaceutical products, sealing and labeling of bags, storage, transportation till final disposal by incineration should be carried out under strict supervision of a suitably qualified and authorized Pharmacist.
- x **Potentially hazardous pharmaceuticals:** Potentially hazardous pharmaceuticals such as cytotoxic, mutagenic and carcinogenic substances should be collected in separate bags and prominently labeled to indicate their contents, chemical formula and potential hazards in addition to the procedure prescribed for disposal of non-toxic pharmaceutical products described above.
- xi Further, potentially hazardous pharmaceuticals should be subject to quarantine and detoxification, where prescribed by the manufacturer, prior to disposal,
- xii **Controlled drugs:** Controlled Drugs including narcotics should also be collected in separate bags and prominently labeled to indicate their contents, in addition to the procedure prescribed above.



- xiii Further, destruction of Controlled drugs should be authorized by the competent authority, provided under rules in force, prior to disposal.
- xiv Always remember that pharmaceutical products, which qualify as Group 'D' Medical Waste, collected in the Yellow, Heavy-Duty Polyethylene bags is still considered potentially hazardous and is 'for incineration only'.
- xv Also remember that pharmaceutical products that qualify as Group 'D' Medical Waste should never be allowed to enter the sewage system.

Important: Empty aerosol and other pressurized containers should not be placed in the Medical Waste bags and containers destined for incineration. Arrangements for collection and disposal of such cans and containers should be made on the basis of special instructions prescribed by the manufacturer of such cans and containers.)

Important: Aerosol cans and pressurized containers containing unused, partially used and expired pharmaceuticals must be returned to the Pharmacy for disposal under strict supervision of suitably qualified and authorized Pharmacist as prescribed.

d (b) Chemicals Substances:

- i Disposal of chemical substances, which qualify as Group 'D' Medical Waste, must be carried out under strict supervision of a suitably qualified and authorized Medical Technologist.
- ii Bottles and containers containing unused, partially used and expired laboratory chemicals, organic solvents, corrosive and inflammable substances must be returned in the original dispensed bottles and container to the pre-designated area in Laboratory from which these were issued.
- iii All such chemical substances should be subject to dilution, neutralization and detoxification, as prescribed by the manufacturer, and rendered harmless prior to disposal.
- iv Always remember that chemical substances including organic solvents and inflammable substances should never be placed in the Medical Waste bags and containers destined for incineration.
- v Also remember that chemical substances that qualify as Group 'D' Medical Waste should never be allowed to enter the sewage system.



c. Group 'E' Medical Waste:

Including: Disposable sheets and covers of bedside receptacles of human secretions or excretions, covers of urine containers and items used to dispose of urine, feces and other bodily secretions or excretions, including but not limited to disposable bed pans or bed pan liners, stoma bags and urine containers.

- i Group 'E' Medical Waste should be collected in the prescribed yellow, medium-duty polyethylene bags, as specified in this 'code of practice'.
- ii The bags should be mounted on sack holders and placed in secured area accessible to the staff on duty but not easily accessible to the general public, at each location where group 'E' medical waste is generated.
- iii The bags should be sealed, labeled and replaced at least once daily or when 65 % full, whichever is earlier.
- iv The bags should be 'carefully sealed' with a purpose made plastic tie or closure or heat sealed if such a facility is available.
- v The sealed bags should be properly labeled indicating the name of the health facility, the location of generation of medical waste, the date and time of sealing the bag and the destination for final disposal.
- vi The sealed and labeled bags should be left at a safe pre-determined location for collection and transportation for disposal.
- vii Only a 'permanent marker pen' or pre-printed 'Hi Tech' non-removable self-adhesive labels should be used for labeling the bags.
- viii Always remember that Group 'E' Medical Waste, collected in the Yellow, Medium-Duty Polyethylene bag is hazardous and is 'for Incineration only'.

Important: (In case categorization of Group 'E' Medical Waste is doubtful and not guaranteed, then the waste must be collected in Red, Heavy-Duty Polyethylene Bags prescribed for Group 'A' Medical Waste.)

Important: (Group 'A' and Group 'E' Medical Wastes are both infectious and differ only in magnitude of potential hazards. Further the mode of storage, transportation and disposal by incineration of both categories of waste is similar. Accordingly, collection of Group 'E' Medical Waste in Red, Heavy-Duty, Polyethylene Bags along with Group 'A' Medical Waste is permissible for reasons of convenience and economy of space. But the reverse is not permissible under any circumstances.)



I. Group 'F' Medical Waste:

Including: Radioactive waste generated during diagnosis and therapy.

- i The radioactive waste that qualifies as Group 'F' Medical Waste is essentially generated under the observation and supervision of qualified persons authorized and licensed to handle such radioactive materials.
- ii The disposal of such radioactive materials is also guided and controlled by national and international organizations responsible for health physics and radiation protection.
- iii Accordingly policies, procedures and guidelines for radioactive waste are to be notified separately and practiced only by authorized persons.

g. Summary Table:

- i The following table gives a summary of the types of bags and containers with the prescribed warning sign, required for each category of medical waste.
- ii It is recommended that this table should be pasted on the notice board of every department, ward, unit and service area of the health facility where medical waste is handled.

Type of Waste	Type of Container	Warning Sign
Medical Waste Group 'A'	Red, Heavy Duty Polyethylene Bags	Highly Infectious Material For Incineration Only
Medical Waste Group 'B'	Yellow, Rigid Sharps Containers	Contaminated Sharp Objects For Incineration Only
Medical Waste Group 'C'	Blue, Heavy Duty Sterilizable Bags	Highly Infectious Material Sterilize Before Disposal
Medical Waste Group 'D'	Yellow, Heavy Duty Polyethylene Bags	Toxic Material For Incineration Only
Medical Waste Group 'E'	Yellow, Medium Duty Polyethylene Bags	Hazardous Material For Incineration Only

- iii Under no circumstances the medical waste bags or sharps containers should be used for any other purpose than those prescribed above.



3. COLLECTION AND REMOVAL:

- a. Collection and removal of sealed and labeled bags and containers requires skilled portering staff and designated medical waste handling trolleys to ensure utmost safety during collection and transportation of bags and containers within the health facility with minimum chances of leakage or spillage of their contents.
- b. The designated trolleys:
 - i should be leak-proof, robust and sturdy in construction;
 - ii should be designed for efficiency in loading and unloading of bags and containers as well as ease in cleaning, washing and disinfection; and
 - iii should be clearly and boldly labeled: 'Medical Waste for Disposal'.
- c. Before removal from source, the portering staff must ensure that all bags and containers are securely sealed and correctly labeled.
- d. All the bags and containers so collected must be transported to a secured area designated for storage of medical waste, before transportation to the point of final disposal.
- e. The designated medical waste handling trolleys must be washed and cleaned every day after use and disinfected at least once a week.
- f. Collection and removal of waste bags and containers should be performed frequently and repeatedly. This frequency could vary from 2 to 4 hours in a large and busy health facility, to not less than once a day in a smaller and less busy health facility.
- g. Medical waste from the infectious disease wards and isolation rooms, if collected separately for clinical reasons, should be removed under the guidance of the Infection Control Nurse.
- h. All human tissues and animal carcasses or tissues should be collected separately and their incineration witnessed or verified.

Important: Domestic waste collected in black bags, and requiring disposal by sanitary landfill, must be handled completely separately from the medical waste at all times during segregation, containment, collection, removal, storage and transportation to final destination for disposal.



4. STORAGE WITHIN THE INSTITUTION:

- a. Every health facility generating medical waste must provide a designated area for storage of bags and containers after collection from the clinical areas and before transportation to the final destination for disposal.
- b. The designated area for storage of medical waste:
 - i should be completely secured and accessible only to authorized staff to avoid any tampering of bags and containers during storage; and
 - ii should be large enough to facilitate storage of medical waste for two to three days to cover holidays and to provide for any contingency or temporary breakdown in the arrangements for transportation of medical waste to its final destination for disposal.
 - iii should be conveniently located within the health facility and should be easily accessible from outside for transportation of waste;
 - iv should be completely separate from the area where domestic waste is collected and stored to avoid any mixing between the domestic and medical wastes; and
 - v should be sited away from other hospital services and should not be located in the midst of general route of public movement.
- c. The designated storage area for medical waste in health facilities:
 - i should preferably be purpose built and should be refrigerated if the medical waste is likely to accumulate for more than one day before transportation for disposal;
 - ii should be sited on a well drained, impervious, hard-standing surface and should be equipped with wash down facilities;
 - iii should be well lit and ventilated and should be secured with self closing heavy duty doors openable from inside to prevent staff from getting accidentally trapped;
 - iv should have staff utilities, change rooms and storage for protective equipment and materials to deal with spillage of medical waste; and
 - v should have facilities for washing and disinfection of designated medical waste trolleys and other equipment and tools used in collection, transportation, storage and disposal of medical waste.



- v must be provided with mobile telephone link to ensure ease in communication.
- e. All tools and appliances used for loading and unloading of medical waste should also be designed to facilitate efficient loading and unloading operations without risk of damaging, ripping or piercing the bags and containers.
- f. Full precautions must be taken to ensure utmost safety during transportation of bags and containers of medical waste without risk of leakage, spillage or outflow of their contents during transit.

6. FINAL DISPOSAL:

- a. Disposal of medical waste must be carried out:
 - i in accordance with the statutory requirements, health and safety and environmental protection regulations, and as per the standing code of practice,
 - ii at designated sites suitably equipped and adequately staffed to undertake disposal of medical waste properly and safely by incineration or any other method prescribed for the purpose,
 - iii by skilled staff under proper direction and supervision.
- b. Disposal by Incineration:
 - i Incineration is the preferred method for disposal of all categories of medical waste.
 - ii Incineration entails complete combustion of medical waste to produce sterile residue suitable for landfill, while keeping the emissions within permissible levels.
- c. Incinerators used for disposal of medical waste should be purpose built for the required capacity of medical waste and should meet the approved standards of design, construction and operation.
- d. Incinerators must also comply with the regulations regarding performance standards applicable to medical waste, including but not limited to the following:
 - i Safe Loading Mechanism,
 - ii Emission Limits & Controls,
 - iii Post Combustion Temperature,
 - iv Flue Gas Treatment,
 - v Safe Disposal of Residues, and



- d. In case the health facility is equipped with an in-house incinerator, then the designated storage area for medical waste should be located in close proximity to the incinerator so that the medical waste could be transported directly from the point of generation to the designated storage area near the incinerator in one single operation.
- e. Record of inflow and outflow of medical waste by source, type, quantity and destination must be maintained by the assigned staff in the designated storage area.

Important: Under no circumstances should the medical waste be allowed to accumulate in the wards, corridors or other unsuitable locations, which are neither isolated nor secured.

Under no circumstances should the medical waste be stored in open trolleys accessible to birds and stray animals

Under no circumstances should medical waste be manually compacted.

5. TRANSPORTATION FOR FINAL DISPOSAL:

- a. Loading, transportation and unloading of sealed and labeled bags and containers of medical waste from the designated storage area of various health facilities to the point of final disposal must be carried by the Municipality or an authorized agency.
- b. In the case of in-house incinerators operated by the health facility, loading, transportation and unloading of sealed and labeled bags and containers for final disposal by incineration must be carried out by the health facility or an authorized agency.
- c. The staff deployed for loading, transportation and unloading of medical waste must be trained and skilled for such operations and must be provided with protective clothing for their safety.
- d. All vehicles and carriages used for transportation of medical waste by road:
 - i must be manufactured and equipped to specifications or suitably modified for safe transportation of medical waste during transit;
 - ii must be leak-proof and should be provided with locking device to secure its contents during transit,
 - iii must be robust and sturdy in construction suitable to withstand heavy loads and shocks without breaking or exploding;
 - iv must be well designed for efficiency in loading and unloading operations and ease in washing, cleaning and disinfection; and



vi Minimum Chimneys Height.

- c. Incinerators must also comply with safety standards for operation and maintenance and must have failsafe mechanism against malfunctioning with provision for automatic shutdown during risk of any hazard.

7. NEO-MODALITIES FOR MEDICAL WASTE DISPOSAL:

a. Chemical Sterilization:

- i Industrial and in-house techniques of chemical sterilization of group 'C' medical waste using eco-friendly chemical substances such as per-acetic acid and chlorine dioxide have been developed and their applications are now commercially available for use in hospitals and central laboratories as a reliable alternative to the cumbersome process of autoclaving.
- ii Large-scale applications of this technology are also available for the treatment of voluminous medical waste collected and transported to a central location for disposal.

b. Microwave Treatment:

- i Microwave treatment technology has been developed for sterilization and disposal of medical waste and is being tested for its widespread application. Its merits and efficacy should be investigated for its viability and cost effectiveness.

8. STAFF TRAINING & PROTECTION:

- a. Safe handling and disposal of medical waste from the point of generation and segregation, through collection, storage and transportation, till its final disposal is a demanding process with serious consequences of failure.
- b. Only skilled staff, under vigilant observation of qualified supervisors, should be deployed for each stage of the process. Further, every organization responsible for or connected with the management of medical waste must ensure training of such staff prior to deployment.
- c. Staff training should include but not be limited to the following:
 - i Potential hazard of handling medical waste.
 - ii Identification, segregation and containment.
 - iii Handling, transportation and disposal.
 - iv Precautions for handling and disposal of waste.
 - v Action to be taken in event of spillage or personal injury.



- vi Legal requirements
- d. Staff engaged in management of medical waste:
 - i should be provided with appropriate protective clothing and suitably training in their proper use; and
 - ii should be universally immunized, especially against Hepatitis B

9. ACCIDENTS AND INCIDENTS

- a. The 'code of practice' for safe handling and disposal of medical waste should be followed meticulously to minimize the risk of failure resulting in leakage, spillage and contamination.
- b. Every organization responsible for or connected with the management of medical waste must formulate and enforce a policy for the management of accidents or incidents resulting in leakage or spillage of medical waste, and demanding immediate action to protect the public and staff at risk.
- c. This should include but not be limited to the following:
 - i Procedure for formal reporting of an accident or incident; and
 - ii Procedure for investigating the cause of the accident or incident and recommending measures to prevent a recurrence.

E. RECOMMENDATIONS & CONCLUSION:

- 3. Government of Abu Dhabi has enacted Law No. 4 of 1998 governing Medical Waste. The Law has the following provisions which need immediate consideration:
 - a. Article (1) of the above Law also prohibits any health facility to dispose of its medical waste outside the designated containers, in accordance with the 'Code of Practice' provided by the Ministry of Health.
 - b. Article (8) of the above Law also provides that the Minister of Justice, in consultation with the Municipalities, shall appoint inspectors from the Municipal Departments of Health to enforce the provisions of the Law and penalize the violators.
 - c. Annexure (3) of the above Law provides that the Municipalities shall dispose of the medical waste at selected locations suitably equipped to do so, by incineration or any other method as prescribed by the Ministry of Health.



4. The above provisions of the Law impose a great responsibility:
 - a. upon the Ministry of Health in defining and continuously updating the policies, procedures and guidelines for the management of medical waste; and
 - b. upon the Municipalities:
 - i. to provide infrastructure for collection, transportation and disposal of medical waste, and
 - ii. to enforce the provisions of the Law in the management of medical waste from the point of generation till its safe disposal.
5. It is a challenge that both the Ministry of Health and the Municipalities must face collectively and steadfastly.
6. It is hoped that this Report on 'Safe Handling and Disposal of Medical Waste' will provide necessary technical information required for the accomplishment of the above objectives and serve as a 'Code of Practice' for the management of Medical Waste.
7. The Convenor and the Members of the Technical Committee of the Ministry of Health are proud to be associated with this monumental task.

ABSTRACT IN ARABIC

تعتمد على عملية التقطيع الكيميائي في المعالجة ،بالسة لمستشفيات دى يتم دفن النفايات الطبية في ملاقف خاصة دون وجود أية عمليات معالجة مسبقة لهذه النفايات .

معظم المواد المشعة المستخدمة في مستشفيات الدولة لها نصف عمر قصير. إضافة إلى هذا فإن جميع المستشفيات التي تحتوي على مواد مشعة لها مخازن خاصة لحفظ هذه النفايات المشعة الناتجة حتى يتم التخلص منها. وتستغرق عملية التحزين ما بين اثنين إلى ثلاثة أسابيع وقد تصل إلى ستة أشهر حسب نوعية المادة المشعة. ولقد يشيت التحاليل المحورية للرماد في المستشفيات التي تحتوي على مواد مشعة بأن نشاط هذه المواد تقل من المستوى المسموح به دوليد حسب ما أوصت به وكالة الطاقة الذرية العالمية. كذلك يشيت التحارب التي أجريت على مستخلصات من عبات الراماد بأن تركيز المعادن الثقيلة -غير مادة الكروميوم- أقل من الحد الأعلى والذي يتم على أساسه تصيف هذه المعلومات بالخطرة.

القوانين الاتحادية لإدارة النفايات الطبية في الدولة غير واضحة. حيث يوجد قوانين أو تشريعات عن إدارة النفايات الطبية مع عدم إدراج النفايات المشعة ولكن هذه القوانين والتشريعات غير متبعة بدقة في جميع المستشفيات . بعض المستشفيات قامت بعمل قوانين أو تشريعات فقط لإدارة نفاياتها الطبية. ولكن مراقبة هذه النفايات وطريقة إدارتها ليست قوية. ويوجد بعض القصور في التشريعات والقوانين الخاصة بإدارة النفايات الطبية المشعة سواء من ناحية الجهات المختصة خارج المستشفى أو من الجهات المختصة داخل المستشفى.

تم الترسية على ضرورة وجود هيئة مؤهلة تقوم وبالتعاون ما بين الجهات المختصة والأقسام الأخرى التي تتعلق بإدارة النفايات بوضع قوانين صارمة من أجل إدارة النفايات الطبية و المشعة والمراقبة عليها. ومن أجل القيام بإدارة النفايات الطبية بطريقة صحيحة فقد تمت الترسية بضرورة التعاون ما بين الأقسام المختلفة في المستشفيات من أجل التخلص من النفايات الطبية . بالإضافة إلى هذا فيجب على إدارة المستشفى أن تقوم بعمل برامج تدريبية لوظفياها حتى يكون لديهم وعي كامل بمخاطر التعرض للمواد السامة والمعدية. لهذا يجب على كل مستشفى القيام بتطعيم جميع موظفيها من التهاب الكبد الوبائي مثل المعرضات وعمال النظافة وغيرهم. وأخيرا تم الترسية بأهمية قيام المستشفيات بتحليل جميع الحالات كالنسم والعدوى الناتجة عن التعرض للنفايات الطبية.

ملخص الرسالة

في عام 1993 ومن خلال حملة تنظيف واسعة على شواطئ دولة الإمارات العربية المتحدة ، تم العثور على كميات مختلفة من النفايات التي صفت على إنها نفايات طبية مما أدى إلى ازدياد القلق المتعلق بطرق التخلص وإدارة المخلفات الطبية في الدولة. وبالرغم من هذا فإن الدراسات المتعلقة بتقييم إدارة النفايات الطبية في الدولة لا تزال محدودة ولا توجد دراسات خاصة بتقييم إدارة النفايات الإشعاعية الطبية. من هنا فإن الهدف الرئيسي لهذا البحث هو تقييم إدارة النفايات الطبية في مستشفيات الدولة من حيث إجراءات جمعها ونقلها ومعالجتها وطرق التخلص من هذه النفايات. بالإضافة إلى مقارنة الإرشادات الخاصة بإدارة النفايات الطبية مع تلك الموصى بها من قبل منظمة الصحة العالمية.

ولتحقيق أهداف هذه الدراسة تم توزيع استبيان يحتوي على جميع الإجراءات الواجب اتخاذها عند التخلص من النفايات الطبية. وقد وزع الاستبيان على أربعة عشر مستشفى موجودة في الإمارات المختلفة في الدولة. وأيضاً تم زيارة هذه المستشفيات للتعرف على طبيعة الإجراءات وتقييمها على أرض الواقع ومقارنتها بما جاء في الرد على الاستبيان بالإضافة إلى جمع بعض العينات من مخرفة النفايات الطبية.

ومن خلال هذه الدراسة وجد أن معدل إنتاج المستشفيات من النفايات الطبية هو 1.95 كجم/سرير/يوم مع اختلاف كبير بين المستشفيات المشمولة في هذه الدراسة يتراوح ما بين 0.2-4.5 كجم/سرير/يوم. وعلى الرغم من أن معدل إنتاج الأنواع المختلفة من النفايات الطبية معروفة في كل مستشفى إلا أن معدل إنتاج كل نوع من أنواع النفايات الطبية غير محسوبة.

وجد في هذه الدراسة أن المستشفيات المشمولة تقوم بتصنيف النفايات المعدية والحادة ولكن لا تقوم جميع المستشفيات المشمولة بتصنيف أنواع النفايات الأخرى مثل نفايات الصيدليات والنفايات الكيميائية واسطوانات الغاز. ووجد أيضاً أن جمع نفايات المستشفيات يتم باستخدام نوعين من الأكياس الملونة: الأصفر للنفايات الطبية بأنواعها المختلفة والأسود للنفايات الغير طبية (كمخلفات المكاتب والمطابخ وغيرها). وتبين أن المستشفيات لا تقوم بوضع ملصقات على أكياس النفايات الطبية لمعرفة نوع وكمية النفايات داخل العبوة. ولكن يوجد معظم المستشفيات مخازن خاصة بالنفايات الطبية. وتبين أن معظم المستشفيات تفتقر إلى المقدرة على امتلاك بعض من الاجهزة التي تساعد على معالجة النفايات الأولية قبل التخلص منها وقد يكون السبب في ذلك إلى محدودية القدرات المالية لكل مستشفى أو إلى الاستعانة بالمواد التي تستخدم للمرة الواحدة.

تبين من هذه الدراسة أن عملية المعالجة المستخدمة حالياً للنفايات الطبية في معظم مستشفيات الدولة هي عملية الحرق المحكم وتعتبر معظم هذه المحارق قديمة جداً ولا يتم صيانتها بشكل دوري مع عدم وجود أدوات جيدة للتحكم بالدخان الملوث الناتج عن عملية الحرق. أما بالنسبة إلى المستشفيات الموجودة في أماره أبو ظبي فهي

تقييم إدارة نفايات المستشفيات في الإمارات العربية المتحدة وخاصة النفايات المشعة منها


رسالة مقدمة من الطالبة
مريم أحمد جوعان الطاهري

استكمالاً لمتطلبات الحصول على درجة الماجستير في علوم البيئة

جامعة الإمارات العربية المتحدة

عمادة الدراسات العليا

مايو 2002م



Date Due

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